Basic Demographic Measures

Population Growth Forum

Region 10 Service Center

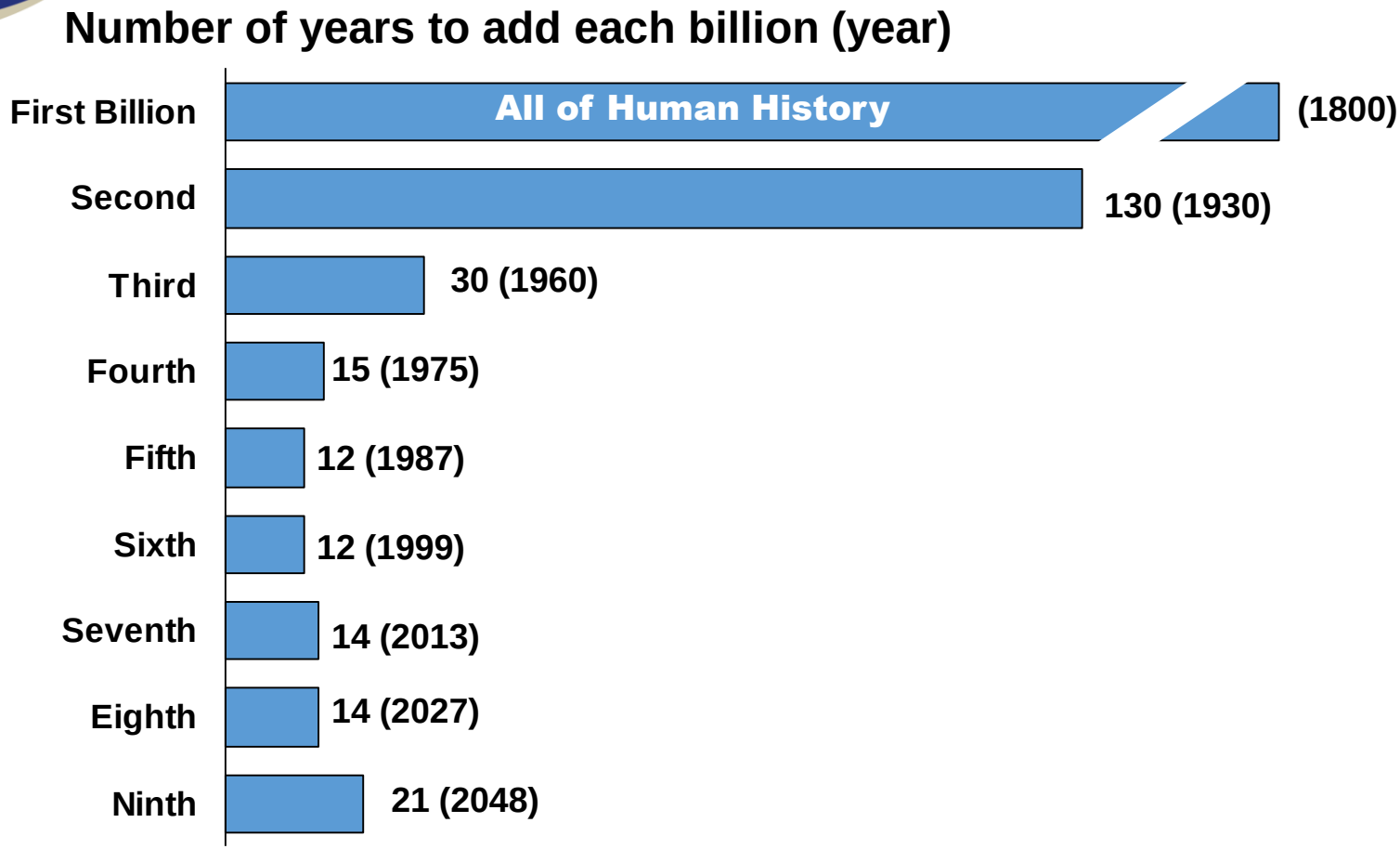
Dallas, Texas

July 14, 2016

TEXAS DEMOGRAPHIC CENTER

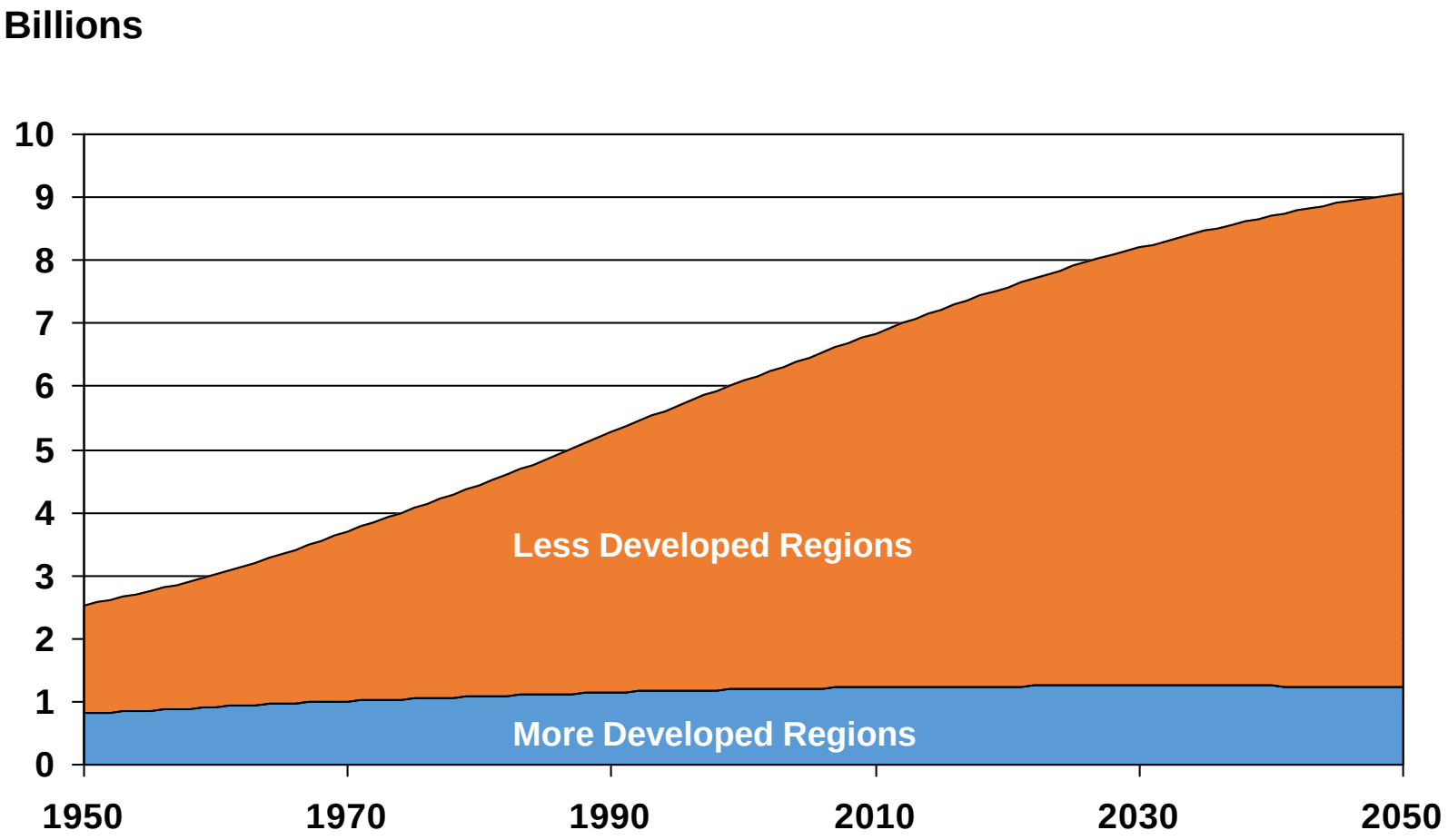
@TexasDemography

World Population Growth, in Billions



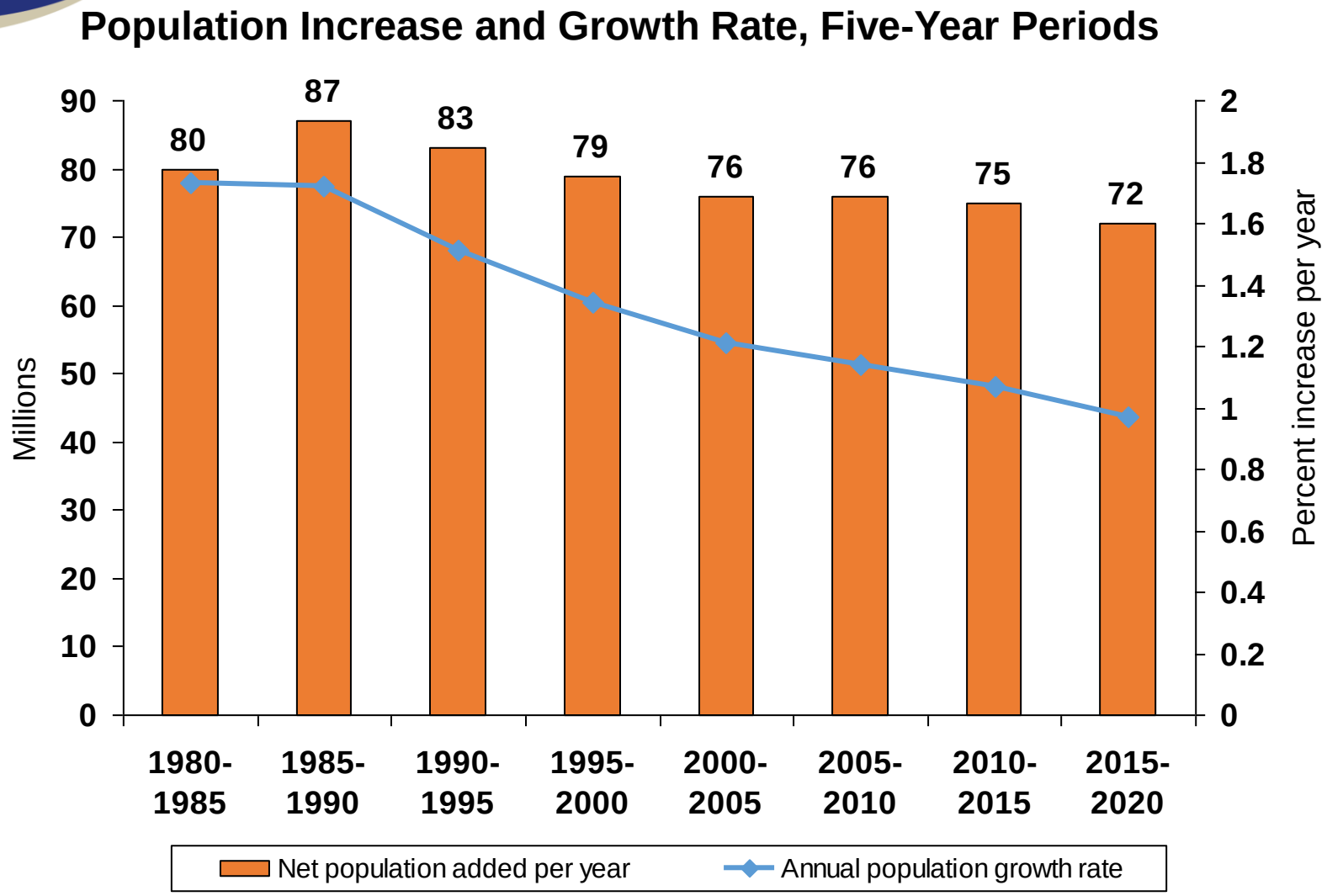
Sources: First and second billion: Population Reference Bureau. Third through ninth billion: United Nations, *World Population Prospects: The 2004 Revision* (medium scenario), 2005.

Growth in More, Less Developed Countries



Source: United Nations, *World Population Prospects: The 2004 Revision* (medium scenario), 2005.

Trends in Population Growth Worldwide



Source: United Nations, *World Population Prospects: The 2004 Revision* (medium scenario), 2005.

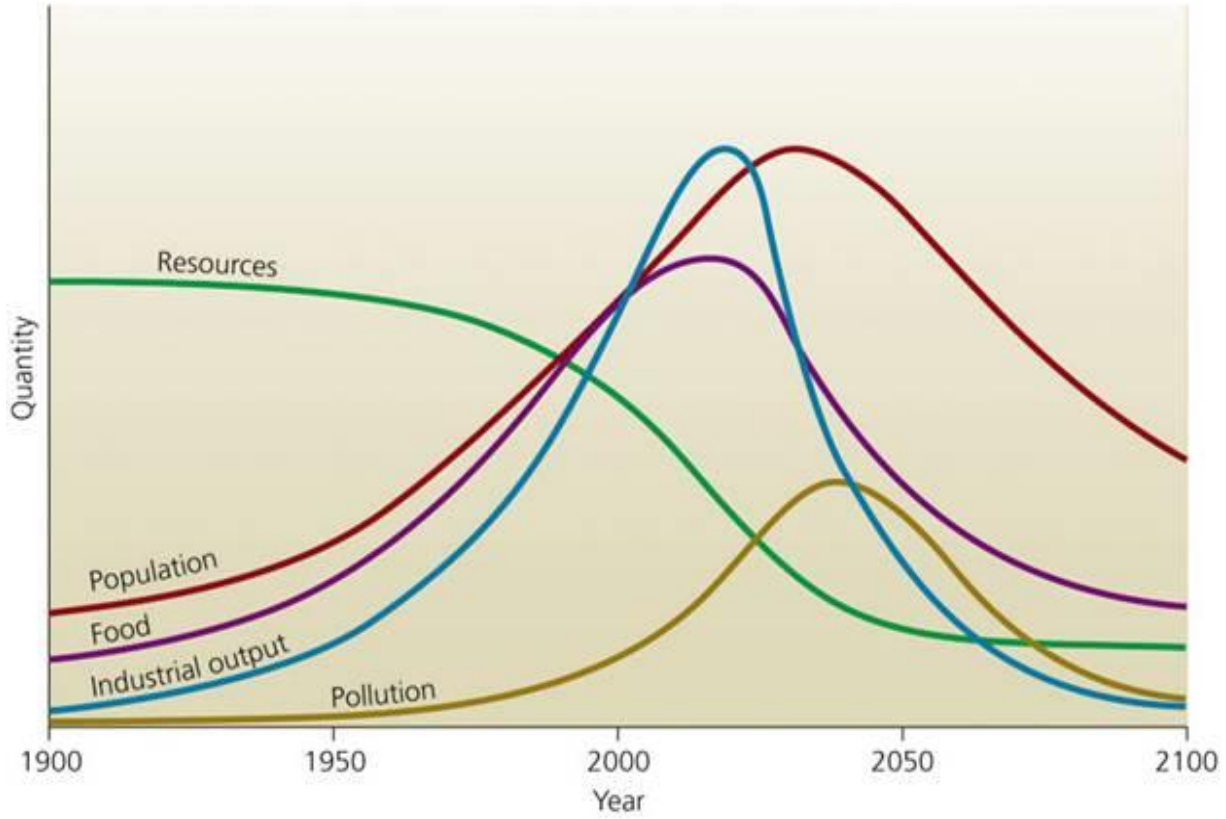
Thomas Malthus

Essay on the Principle of Population

- Relationship between population and resources
- Population growth threatened prosperity because it inevitably outran increases in food supplies
    - agricultural production grew arithmetically, increasing by the same amount over 25 years
    - population grew geometrically, doubling every 25 years

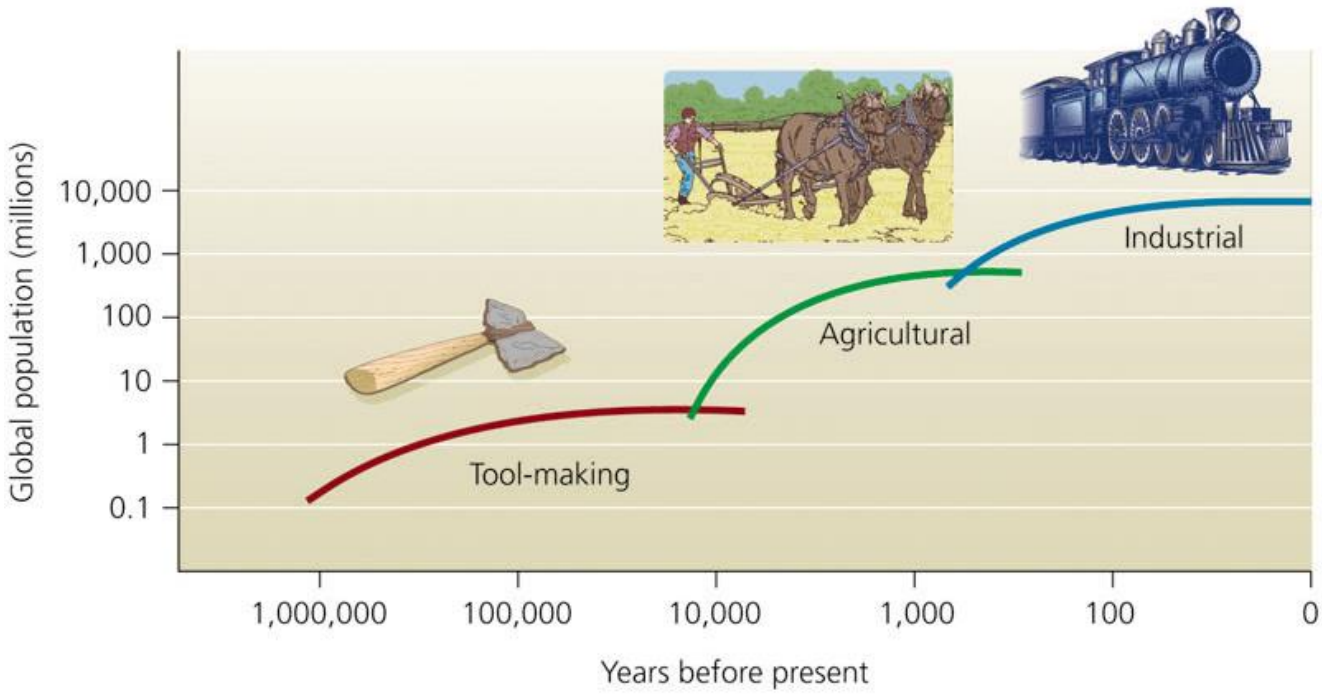
Population Clock

Modeling population and its consequences



Some models show population growth leading to resource depletion, which can result in declining food production, industrial output, and population.

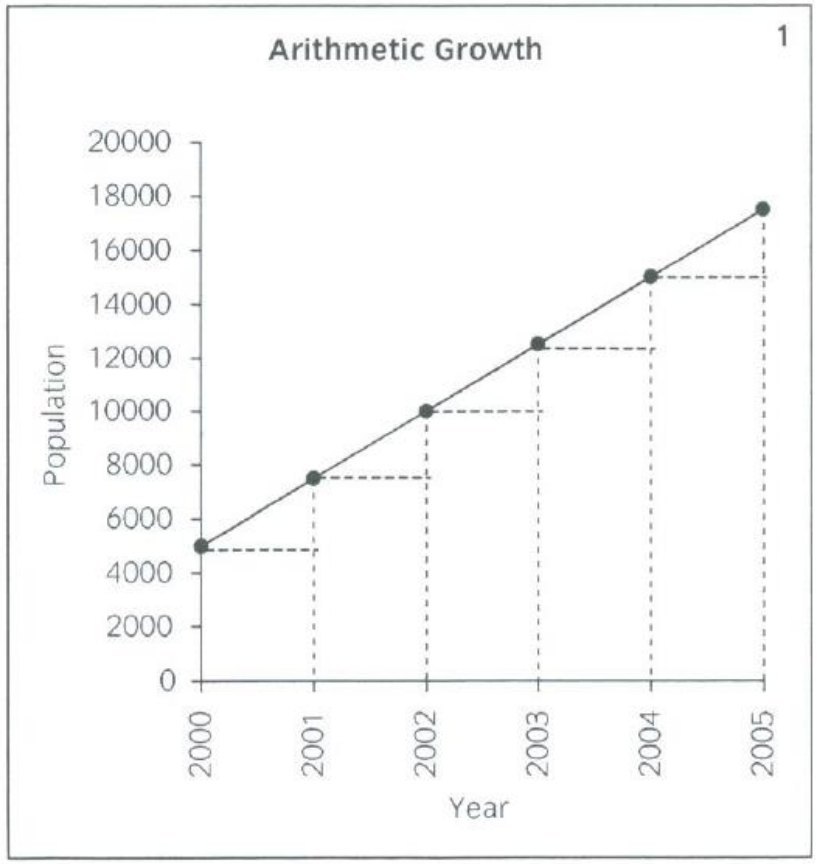
Increasing our carrying capacity



Technology has allowed us to raise Earth's carrying capacity for our species time and again.

Tool-making, agriculture, and industrialization each enabled humans to sustain greater populations.

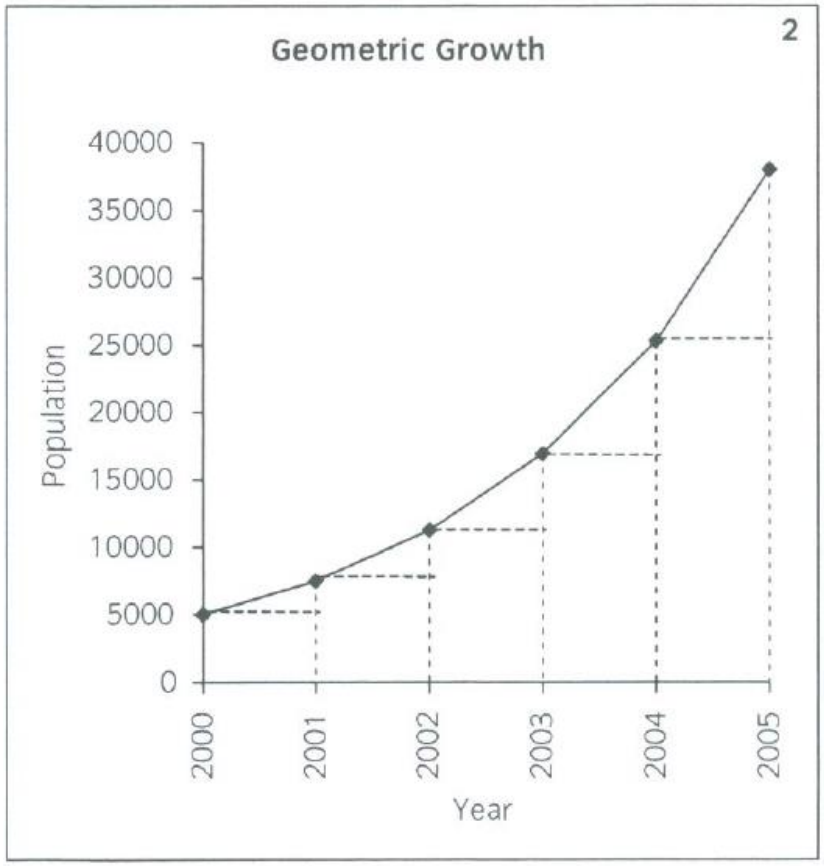
Arithmetic Growth



population increases by a constant number of persons for each period

arithmetic growth entails constant increments

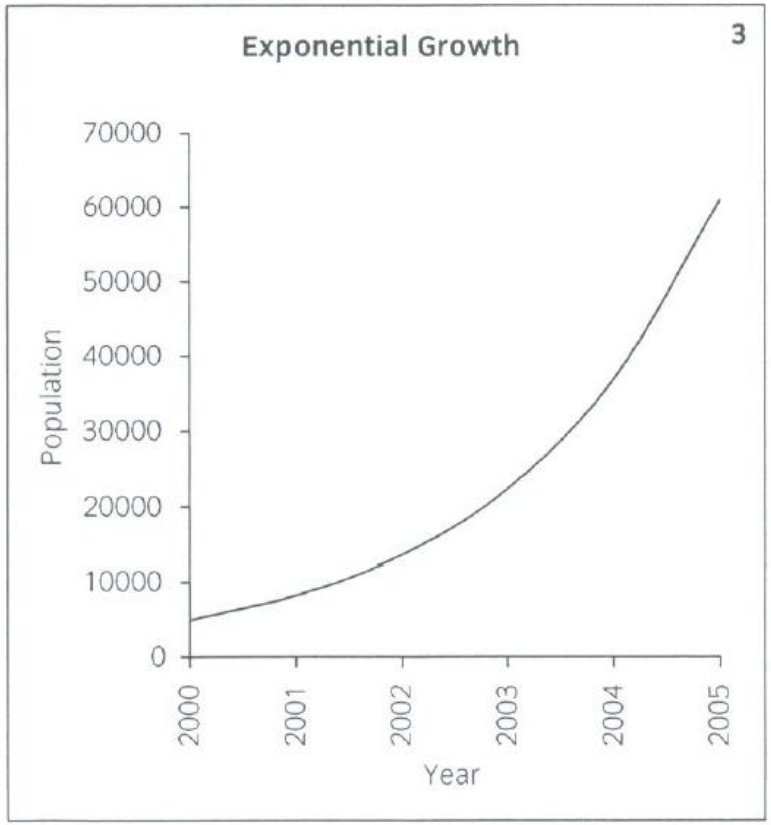
Geometric Growth



Geometric growth entails ever larger increments.

Population increments become larger because increases are self-reinforcing "compound interest"

Exponential Growth

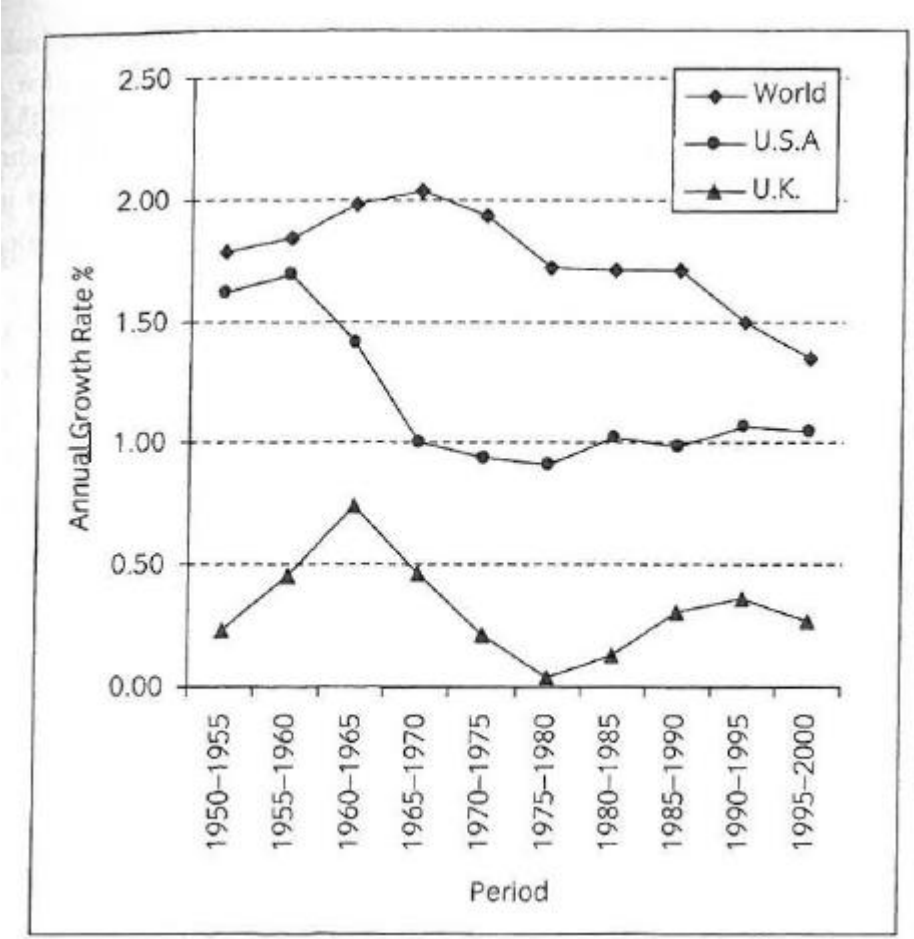


Exponential growth refers to the situation where growth compounds continuously - at every instant of time.

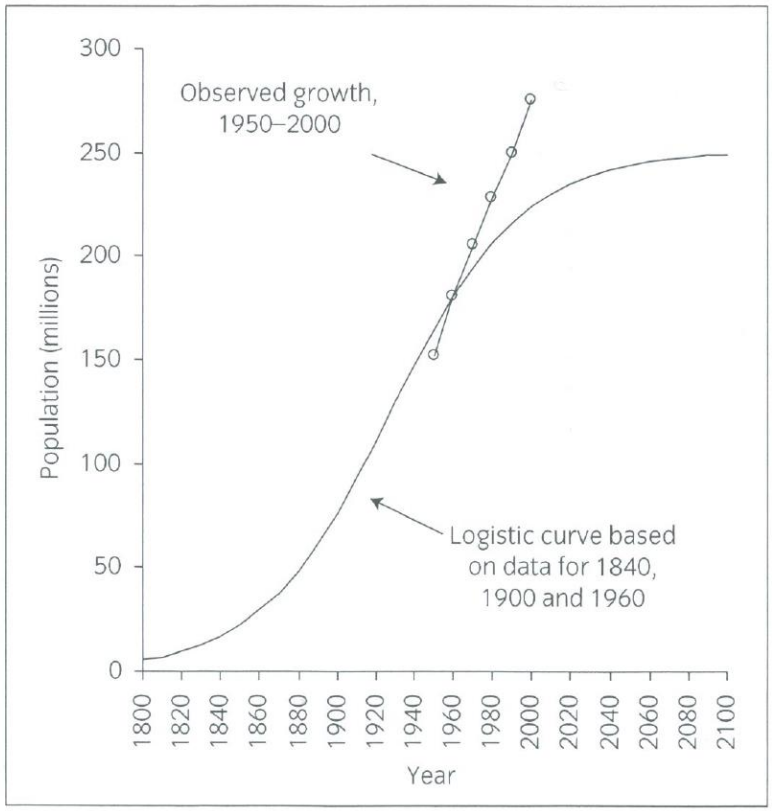
Populations Increasing at Annual Rates of 50%

Year	Type of Growth Rate		
	Arithmetic	Geometric	Exponential
A	B	C	D
Population Totals			
2000	5,000	5,000	5,000
2001	7,500	7,500	8,244
2002	10,000	11,250	13,591
2003	12,500	16,875	22,408
2004	15,000	25,313	36,945
2005	17,500	37,969	60,912
2006	20,000	56,953	100,428
2007	22,500	85,430	165,577
2008	25,000	128,145	272,991
2009	27,500	192,217	450,086
2010	30,000	288,325	742,066
Population Ratios			
$P_1 : P_2$	variable	1 : 1.500	1 : 1.649

Annual Growth Rates



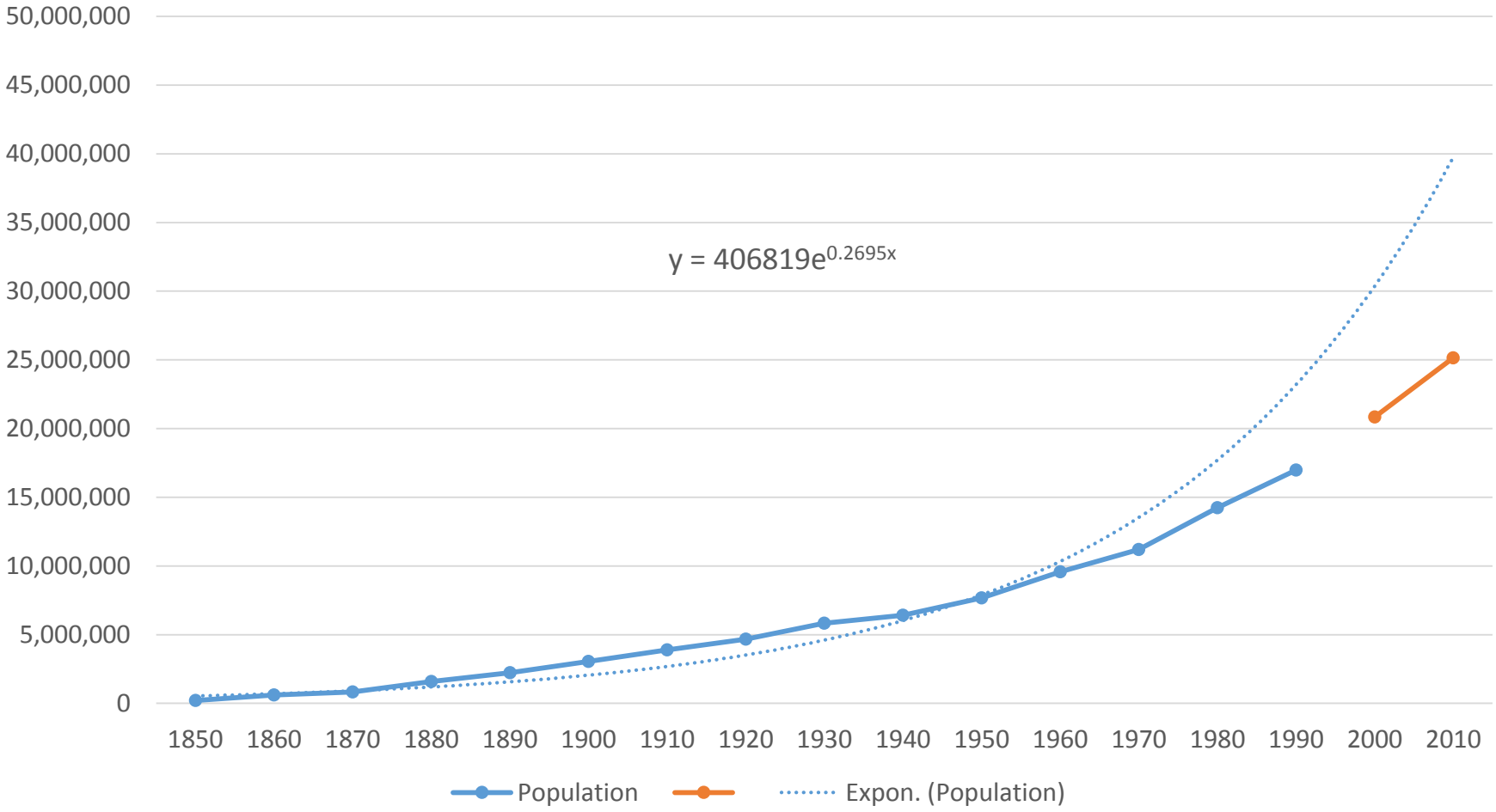
Logistic growth



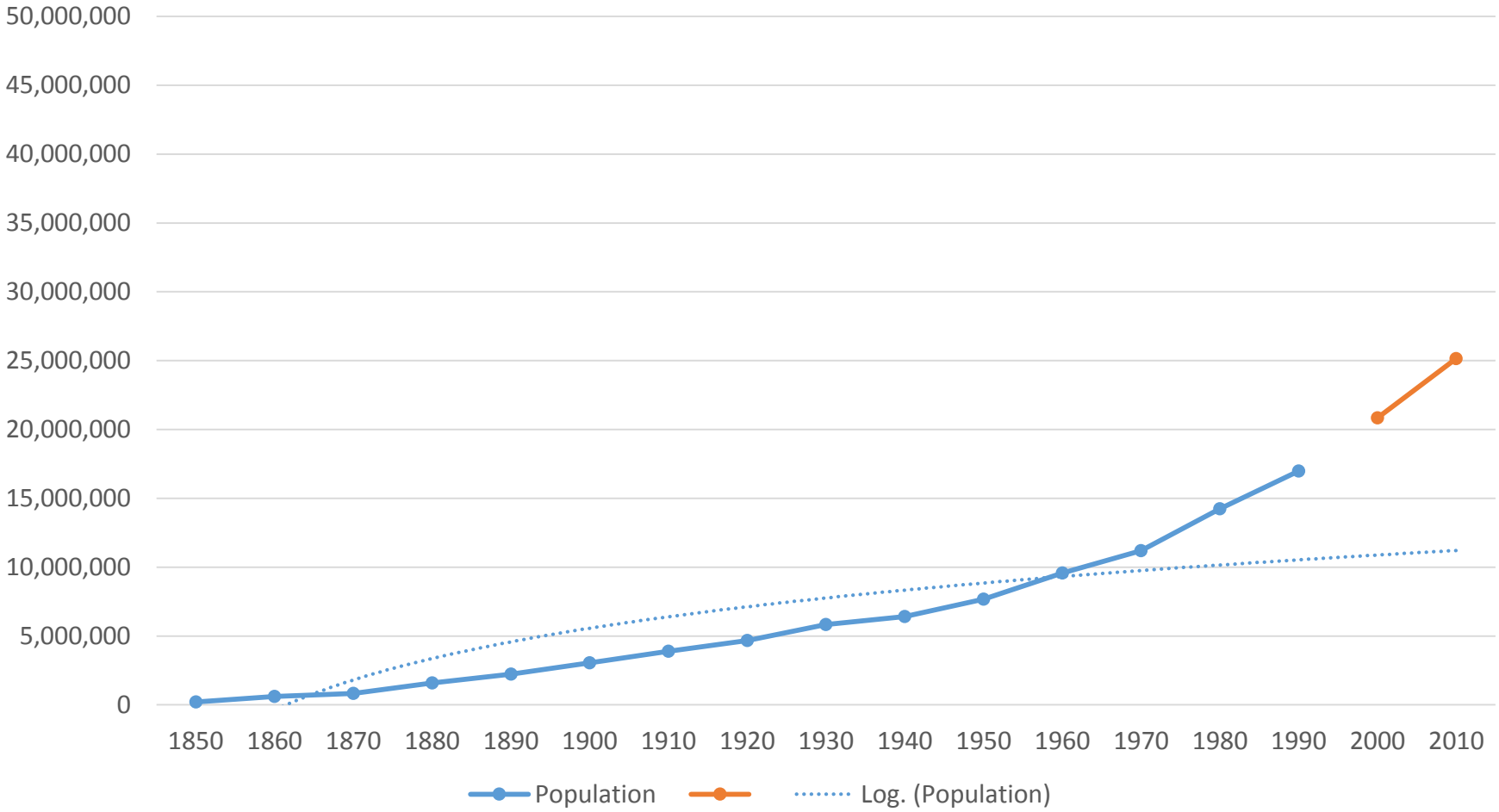
“universal law of population growth”

S-shaped trend is a more realistic depiction of long-run national or global population growth than straight lines or exponential curves

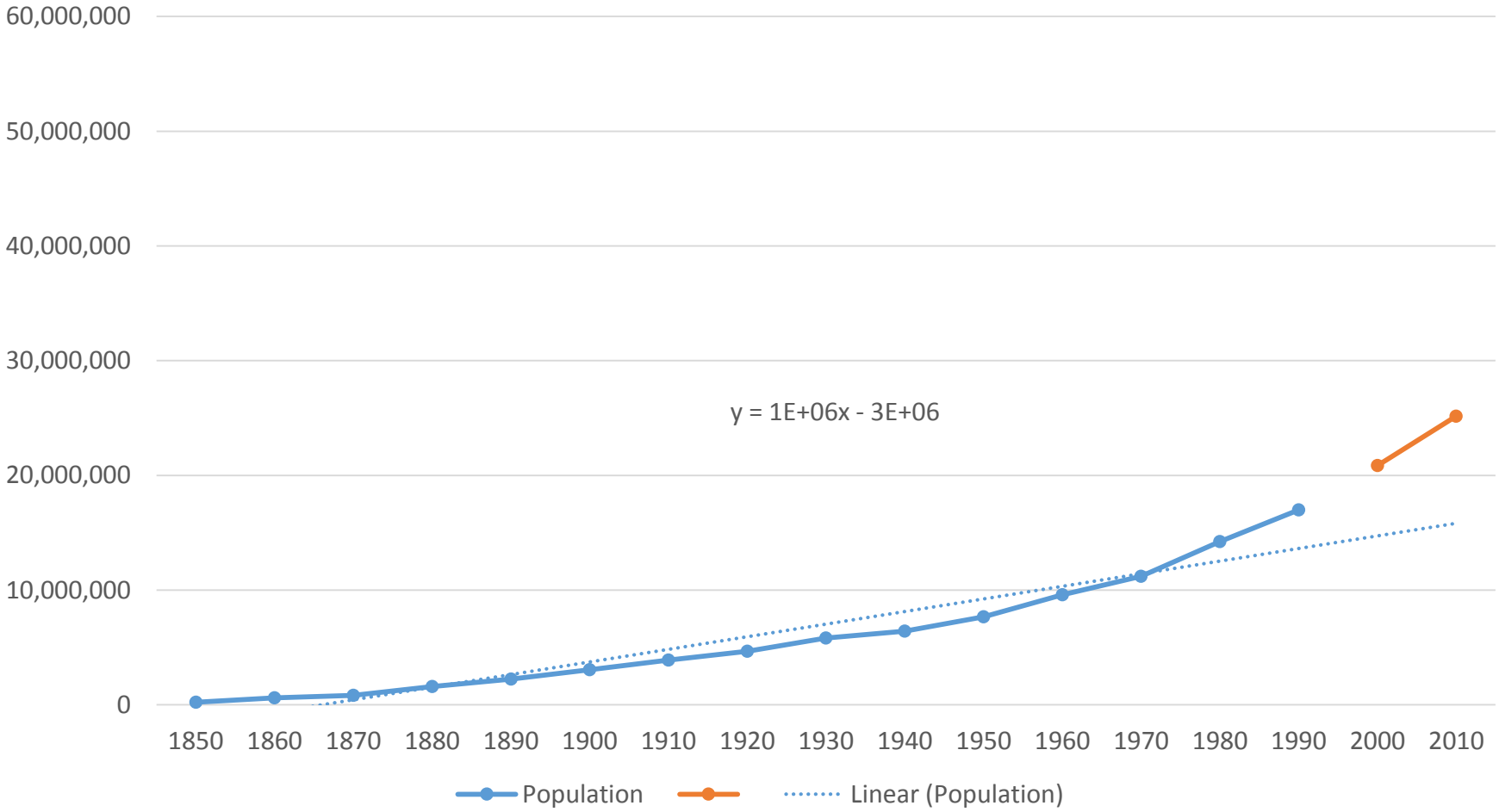
Extrapolation of Texas Population Using Historical Data (1850-1990) -Exponential



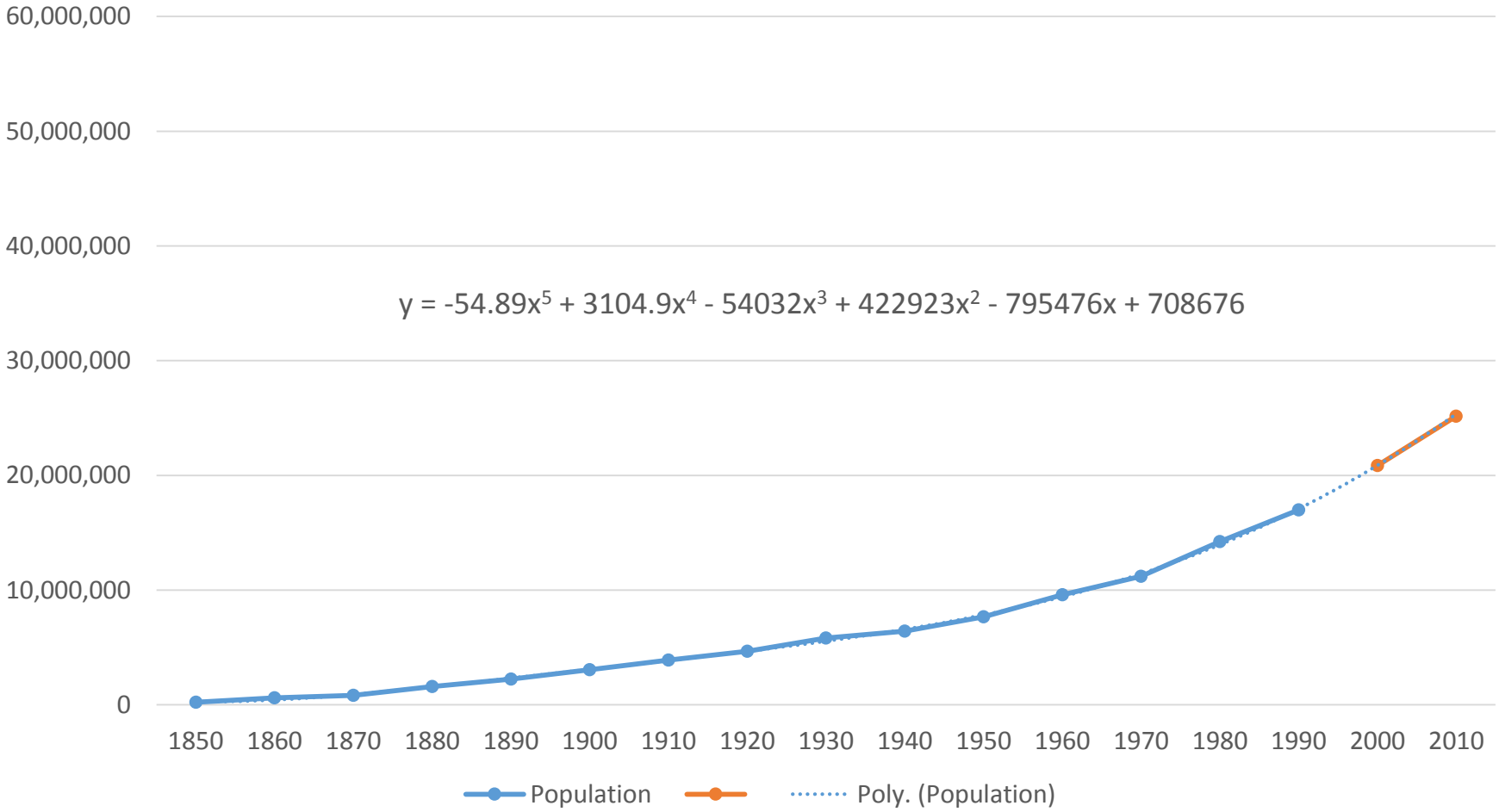
Extrapolation of Texas Population Using Historical Data (1850-1990) - Logistic



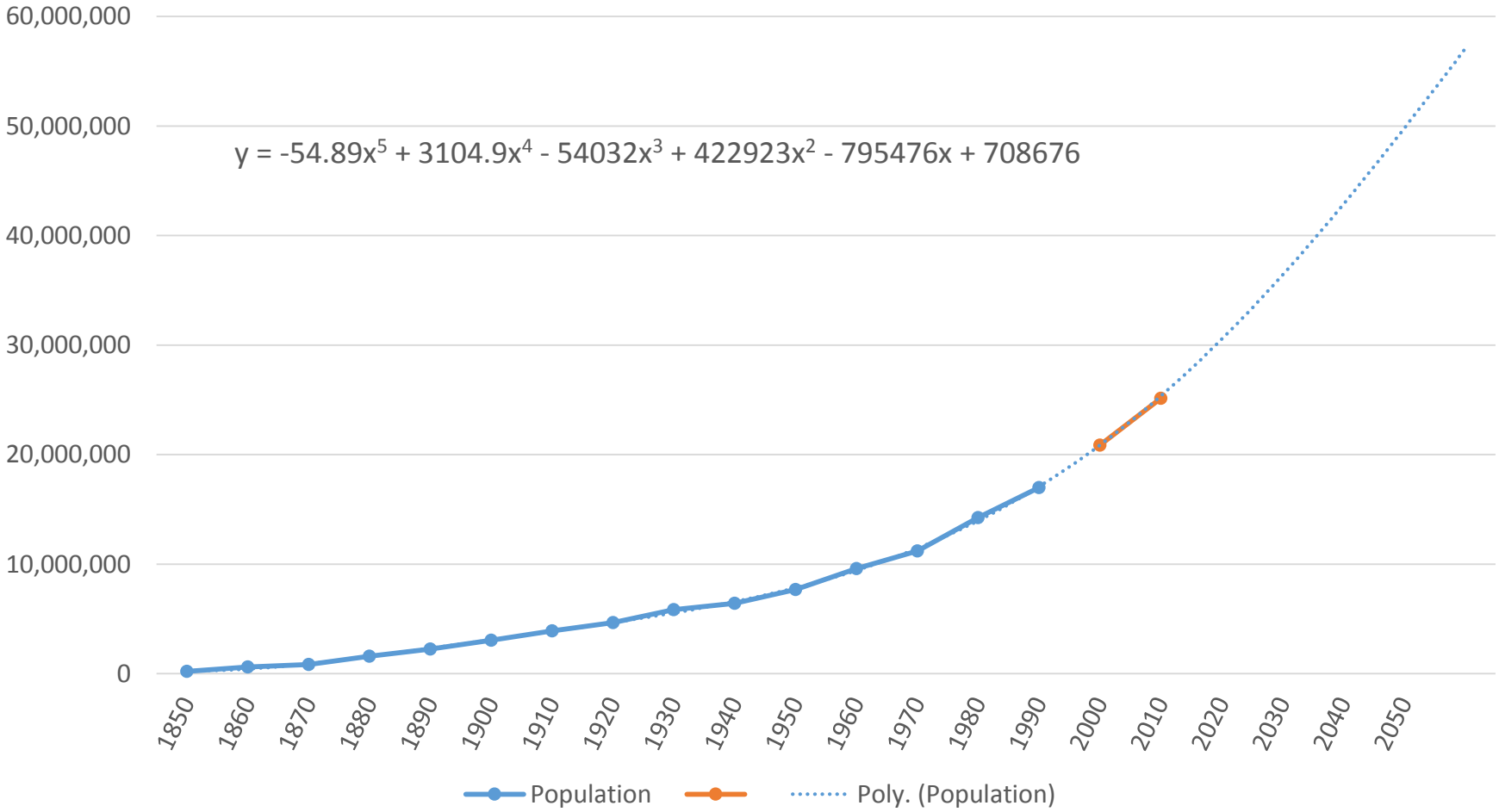
Extrapolation of Texas Population Using Historical Data (1850-1990) - Linear



Extrapolation of Texas Population Using Historical Data (1850-1990) -Polynomial



Extrapolation of Texas Population Using Historical Data (1850-1990) -Polynomial



Analyzing Growth

- Absolute change
- Percent change
- Average annual increase
- Arithmetic growth rate

Formulas	Examples
Definitions P_0 = population at the start, e.g. year zero P_n = population at the end, e.g. after n years n = number of intervals (e.g. years) between P_0 and P_n	*Mexico* P_0 = 98 787 000 (Year 2000) P_n = 162 356 000 (Year 2050) n = 50 years (mid-2000 to mid-2050)
1 *Absolute change* $P_n - P_0$	162 356 000 – 98 787 000 = 63 569 000
2 *Percentage change* $\left(\frac{P_n - P_0}{P_0}\right) \times 100$	63 569 000/98 787 000 × 100 = 64.35%
3 *Average annual increase* $\frac{P_n - P_0}{n}$	63 569 000/50 = 1 271 380
4 *Arithmetic growth rate* $\left(\frac{P_n - P_0}{n}\right) \div P_0 \times 100$	1 271 380/98 787 000 × 100 = 1.29%

Data source: World Bank (1994: 343)

Geometric Growth

- Estimating intercensal numbers, or projecting future population, assuming that the growth rate remains constant (growth rates usually vary through time)

Geometric Growth

Formulas	Examples
Definitions	*United States*
P_0 = population at the start	$P_0 = 250.4$ (millions, mid-1990)
P_n = population at the end	$P_n = 297.2$ (millions, mid 2010)
n = number of intervals between P_0 and P_n	$n = 20$ years
r = annual growth rate	$r = 0.860\,41\%$
1 *End of period population*	
$P_n = P_0 (1 + r)^n$	$P_n = 250.4 \times (1.008\,604\,1)^{20}$ $= 297.2$
or	or
$\log P_n = \log P_0 + \log(1 + r) \times n$	$\log P_n = 2.398\,63 + 0.074\,41$ $\therefore P_n = 297.2$
2 *Initial population*	
$P_0 = \dfrac{P_n}{(1+r)^n}$	$P_0 = 297.2/(1.008\,604\,1)^{20}$ $= 250.4$
or	or
$\log P_0 = \log P_n - \log(1 + r) \times n$	$\log P_0 = 2.473\,05 - 0.074\,41$ $\therefore P_0 = 250.4$

3 *Geometric growth rate*

$$r = \sqrt[n]{\frac{P_n}{P_0}} - 1$$

or

$$\log(1+r) = \frac{\log\left(\frac{P_n}{P_0}\right)}{n}$$

$r = (297.2/250.4)^{(1/20)} - 1$
$= 0.008\,604\,1$ or $0.860\,41\%$

or

$\log(1 + r) = 0.003\,720\,724$
$\therefore r = 0.860\,41\%$

4 *Interval between two populations*

$$n = \frac{\log\left(\frac{P_n}{P_0}\right)}{\log(1+r)}$$

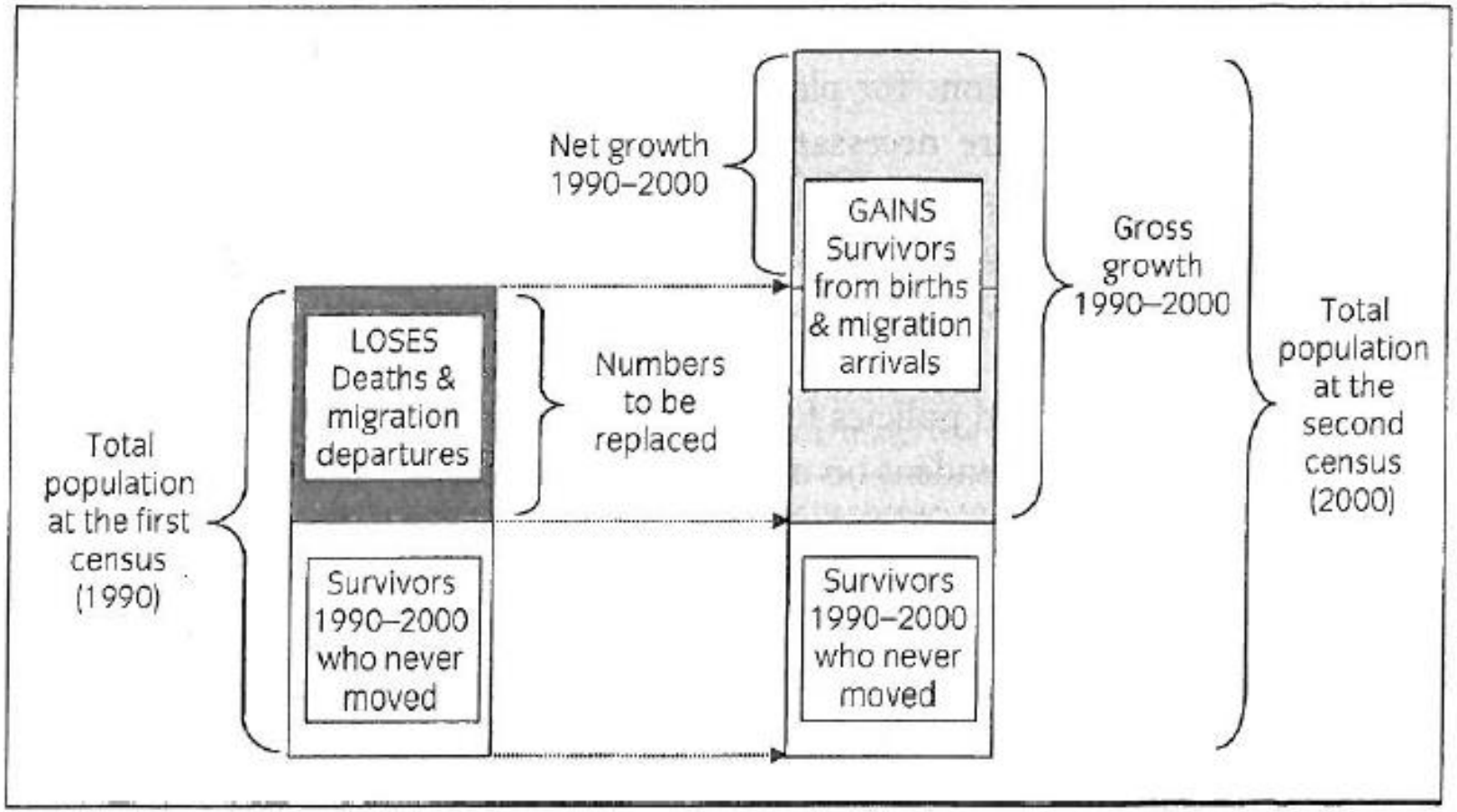
$n = 0.074\,414\,481/0.003\,720\,724$
$= 20$ years

5 *Doubling time*

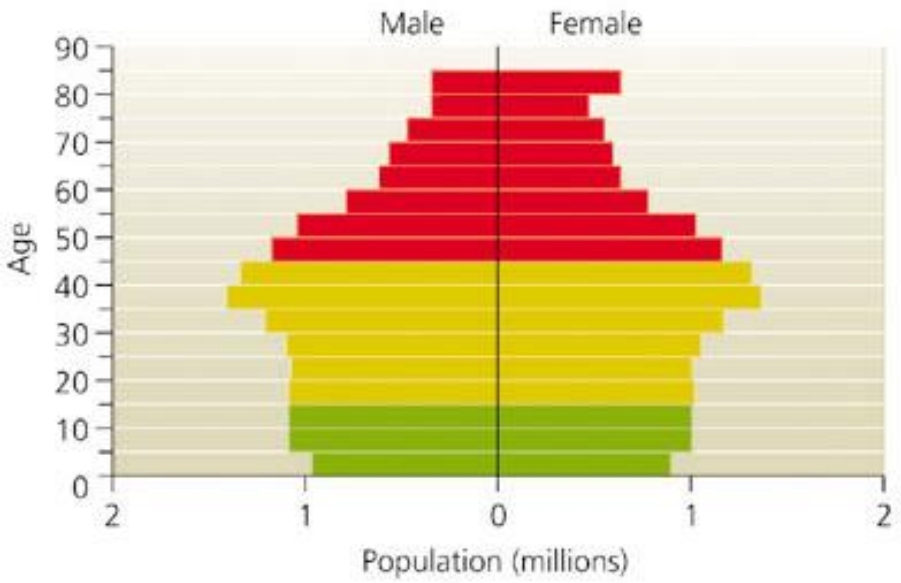
$$n = \frac{\log 2}{\log(1+r)}$$

$n = 0.301\,03/0.003\,720\,724$
$= 80.9$ years

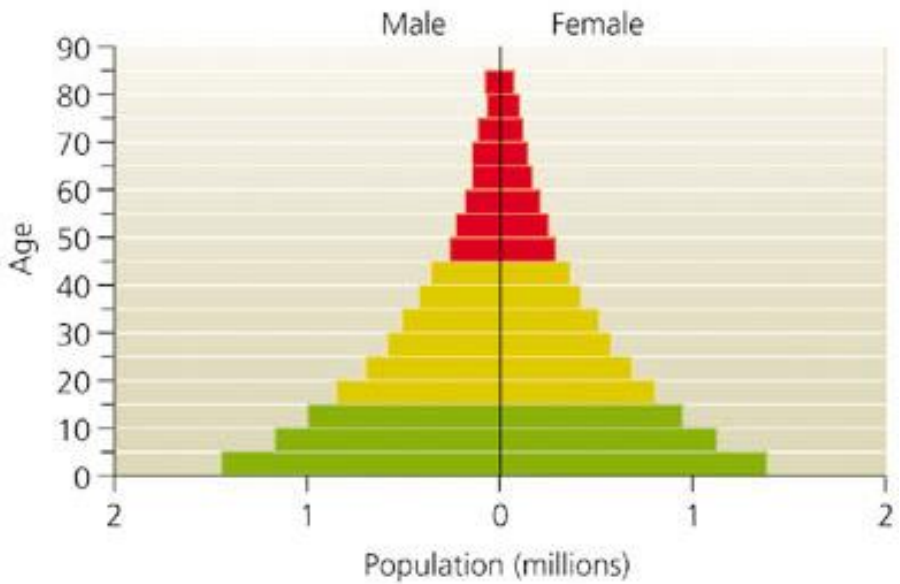
Growth and Replacement



Age structure: Age pyramids



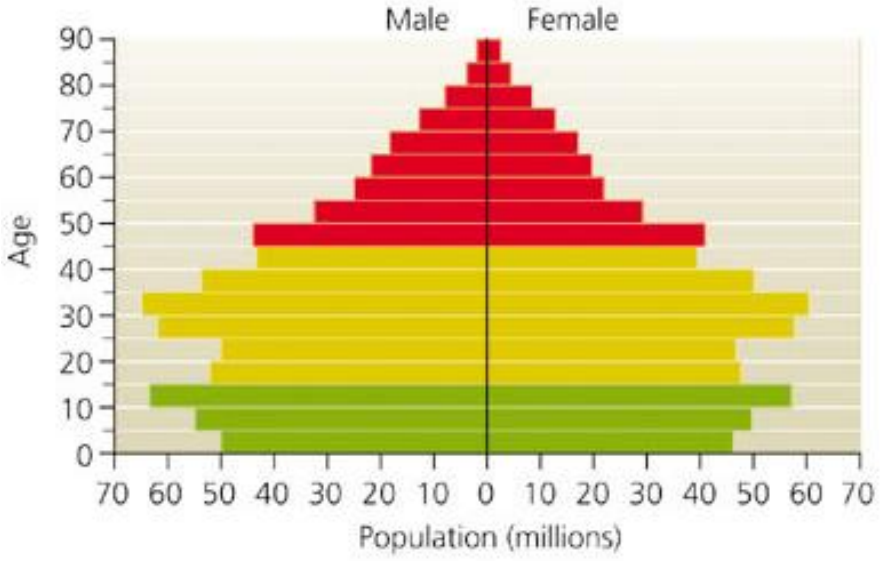
(a) Age pyramid of Canada in 2000



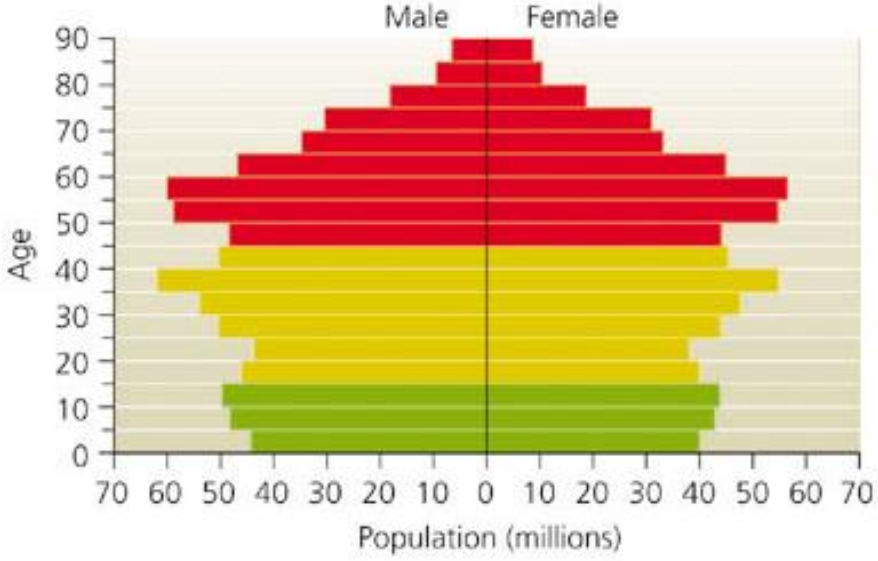
(b) Age pyramid of Madagascar in 2000

Canada (left) has a much slower growing population than does Madagascar (right).

Age structure: “Graying populations”



(a) Age pyramid of China in 2000



(b) Projected age pyramid of China in 2025

Demographers project that China’s population will become older over the next two decades.

Factors affecting population growth rates

Population growth depends on rates of birth, death, immigration, and emigration.

(birth rate + immigration rate)

– (death rate + emigration rate)

= population growth rate

Natural rate of population change

Change due to birth and death rates alone, excluding migration

Is often expressed in % per year

China's natural rate of change has fallen

Table 7.1 Recent Trends in China's Population Growth

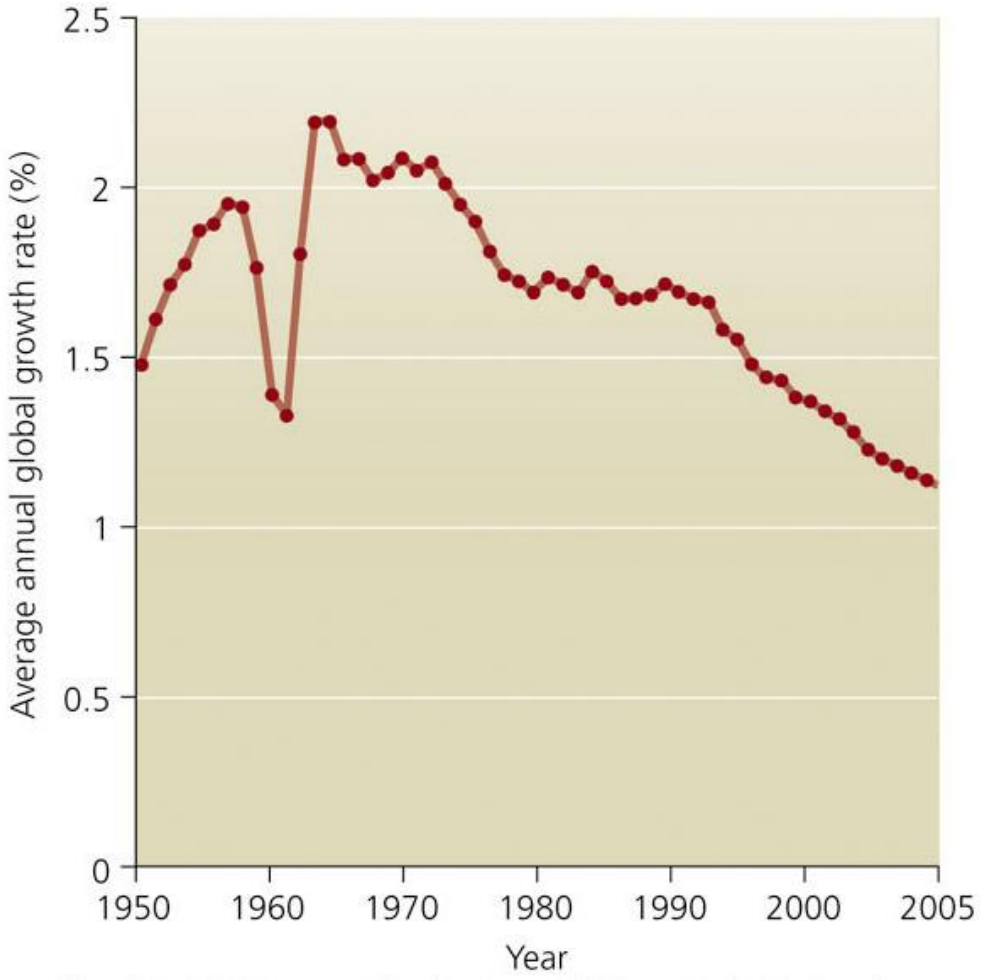
	1970	1993	2002
Total fertility rate	5.8	2.0	1.8
Rate of natural population increase (% per year)	2.6	1.2	0.7
Doubling time (years)	26.9	58.3	100.0

China's rate has fallen with fertility rates. It now takes the population 4 times as long to double as it did 25 years ago.

Global growth rates have fallen

The annual growth rate of the world population has declined since the 1960s.

(But the population size is still rising)



Fertility rates affect population growth rates

Total fertility rate (TFR) = average number of children born per woman during her lifetime

Replacement fertility = the TFR that keeps population size stable

For humans, replacement fertility is about 2.1.

Total fertility rates by region

Region	Total fertility rate (TFR)
Africa	5.2
Latin America and Caribbean	2.7
Asia	2.6
Oceania	2.5
North America	2.1
Europe	1.4

African nations have the highest TFRs.

European nations have the lowest TFRs.

INTERPOLATION OF POINT DATA

- Interpolation - inferring intermediate values in a given series of data by use of a mathematical formula or a graphic procedure.
- Extrapolation - inferring values that go beyond the given series of data by use of a mathematical formula or a graphic procedure.

Summary measures

- Sex ratios $\frac{M}{F} \times 100$
- Dependency ratio $\frac{P_{0-14} + P_{65+}}{P_{15-64}} \times 100$
- Child dependency ratio $\frac{P_{0-14}}{P_{15-64}} \times 100$
- Aged dependency ratio $\frac{P_{65+}}{P_{15-64}} \times 100$
- Economic dependency ratio $\frac{\text{Population not in the labour force}}{\text{Population in the labour force}} \times 100$
- Aging index $\frac{P_{65+}}{P_{0-14}} \times 100$
- Caretaker ratio $\frac{P_{80+}}{P^{f}_{50-64}} \times 100$

Central age – single year digits

- Mean - $\frac{\text{sum of values}}{\text{number of values}}$

- Mode - most frequently occurring value or group

- Median -middle value in a set of numbers arranged in ascending or descending order

Median age

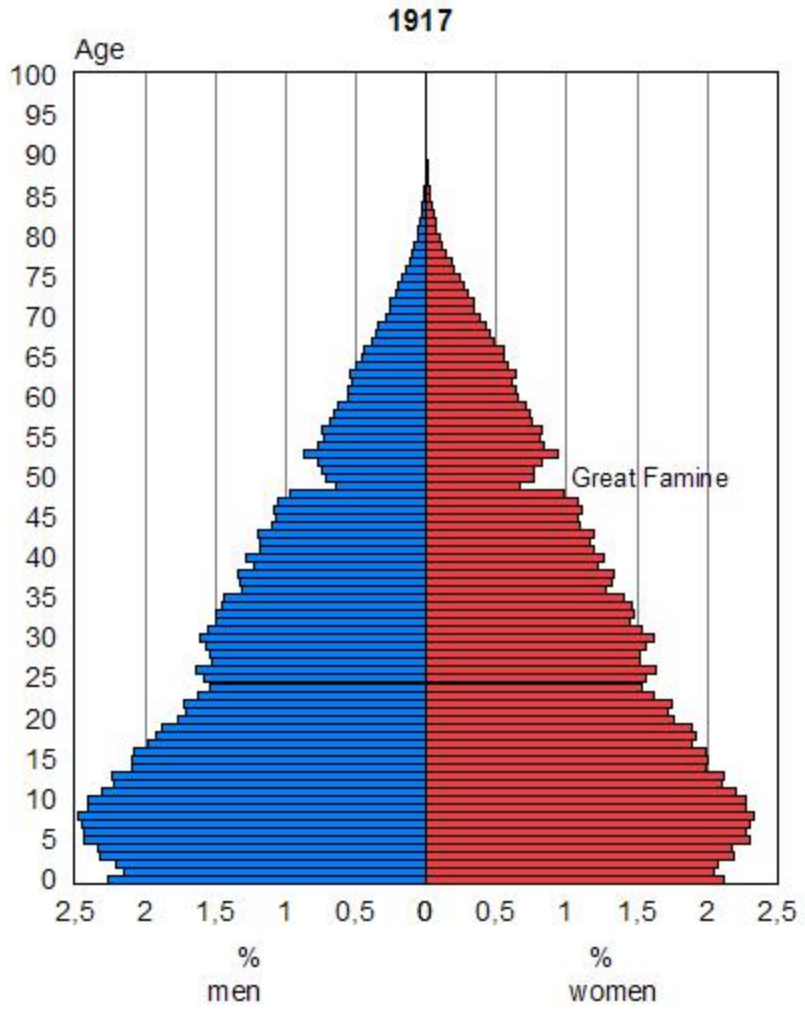
- The median is preferred to the mean because of the marked skewness of the age distribution

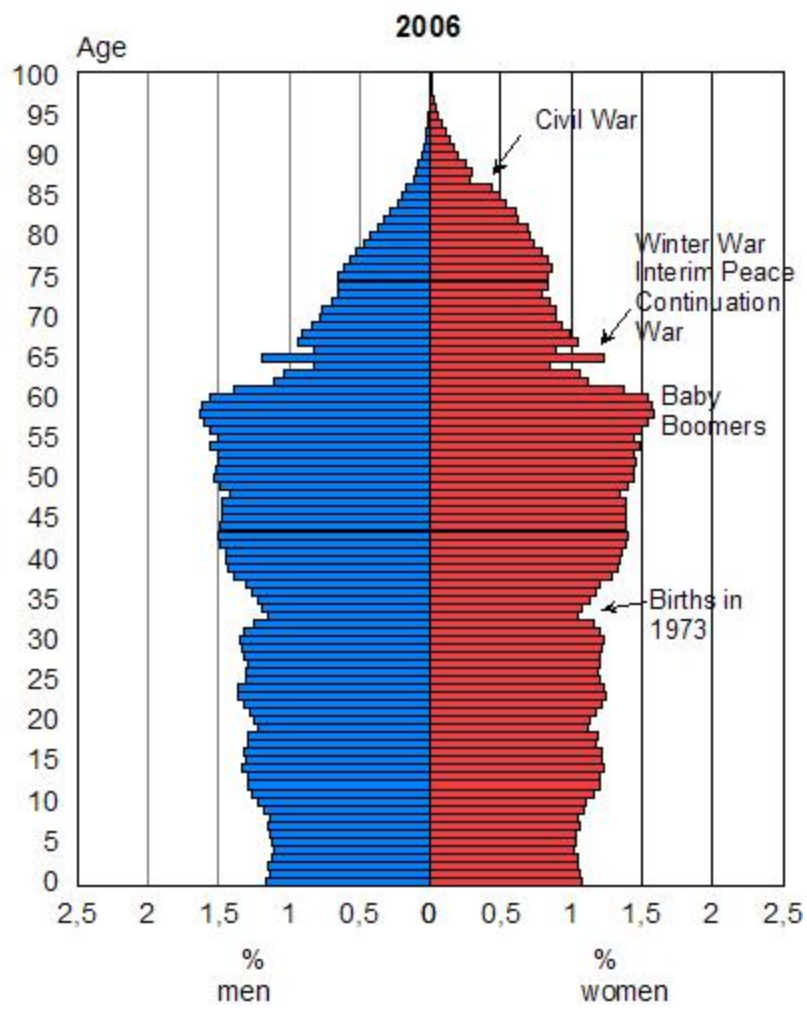
- The calculation of mean is often complicated by open-ended age groups (e.g. 80+)

Age pyramids

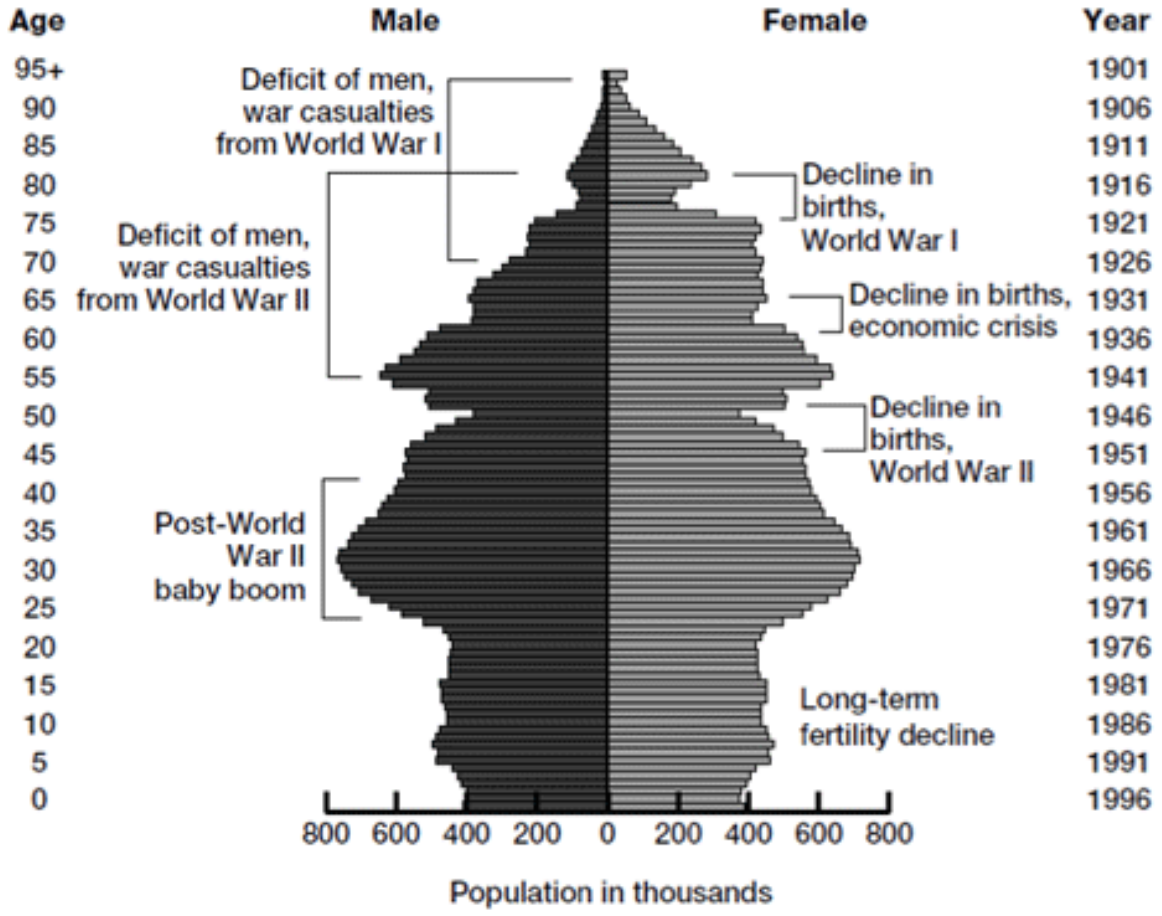
- Gives a detailed picture of the age-sex structure of a population
- Consists of bars representing age groups in ascending order from lowest to highest pyramided on one another
- Bars are generally by single or 5-year age groups
- Number (or percentage) of persons in an age group is indicated by length of its bar from central axis
- Males on left side; females on right side
- Pyramids with absolute numbers show differences in overall sizes of total populations and in number at each age
- Percent pyramids show relative differences in population size at each age-sex group

Age structure of Finnish population in 1917 and 2006



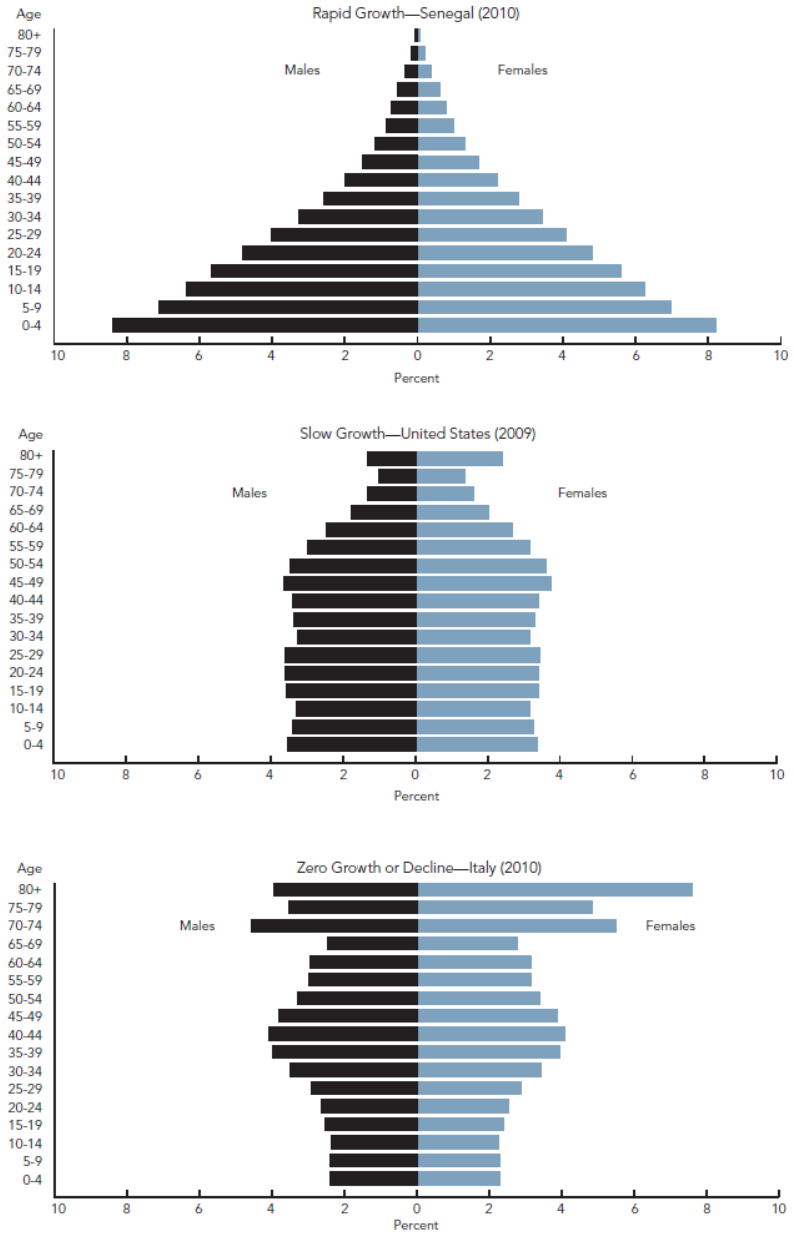


http://www.stat.fi/tup/suomi90/joulukuu_en.html



Germany's population by age and sex, 1996. Source: Population reference bureau

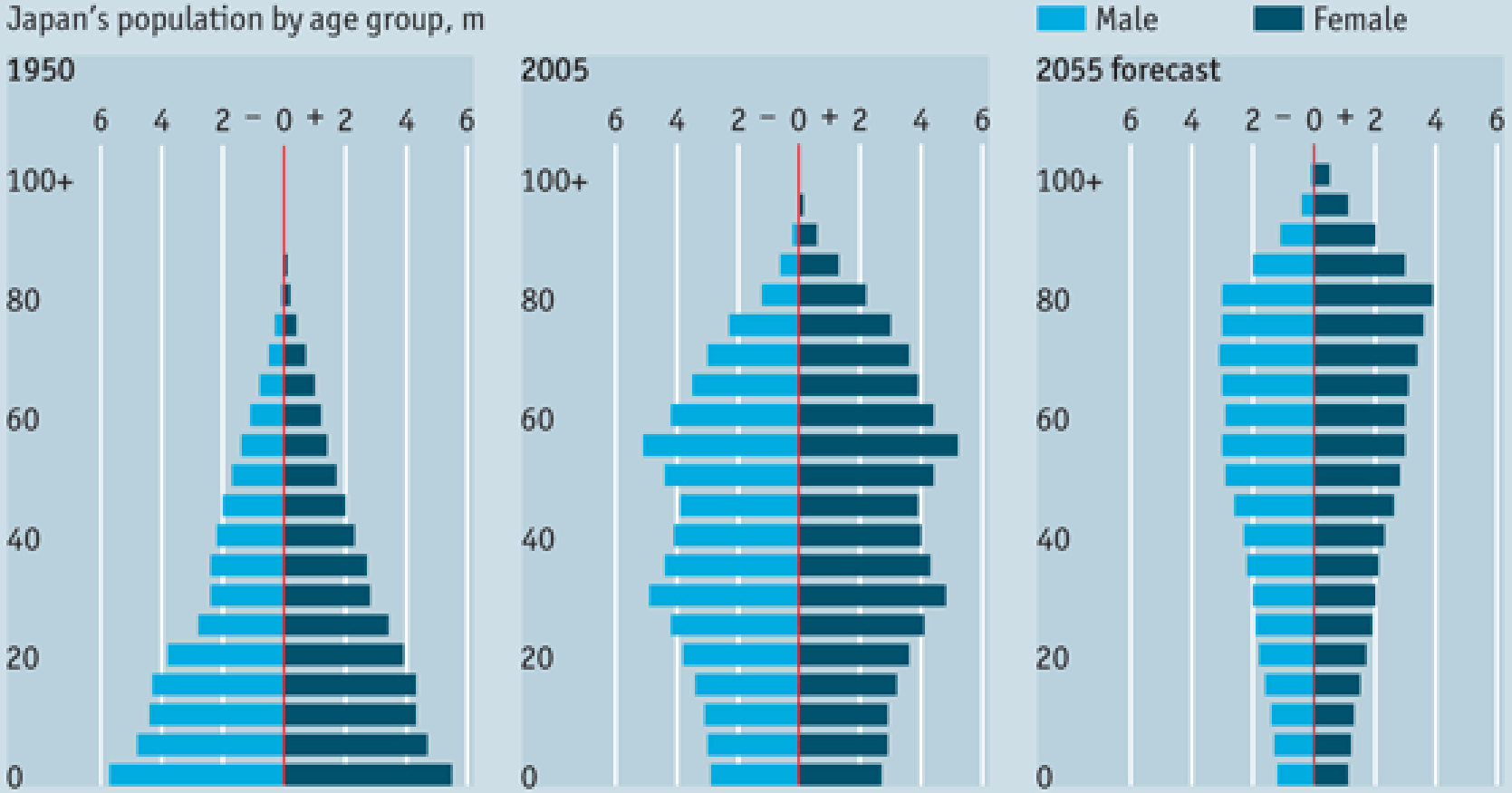
Population Pyramids: Senegal, United States, and Italy



Sources: United Nations Population Division; U.S. Census Bureau; and ISTAT.

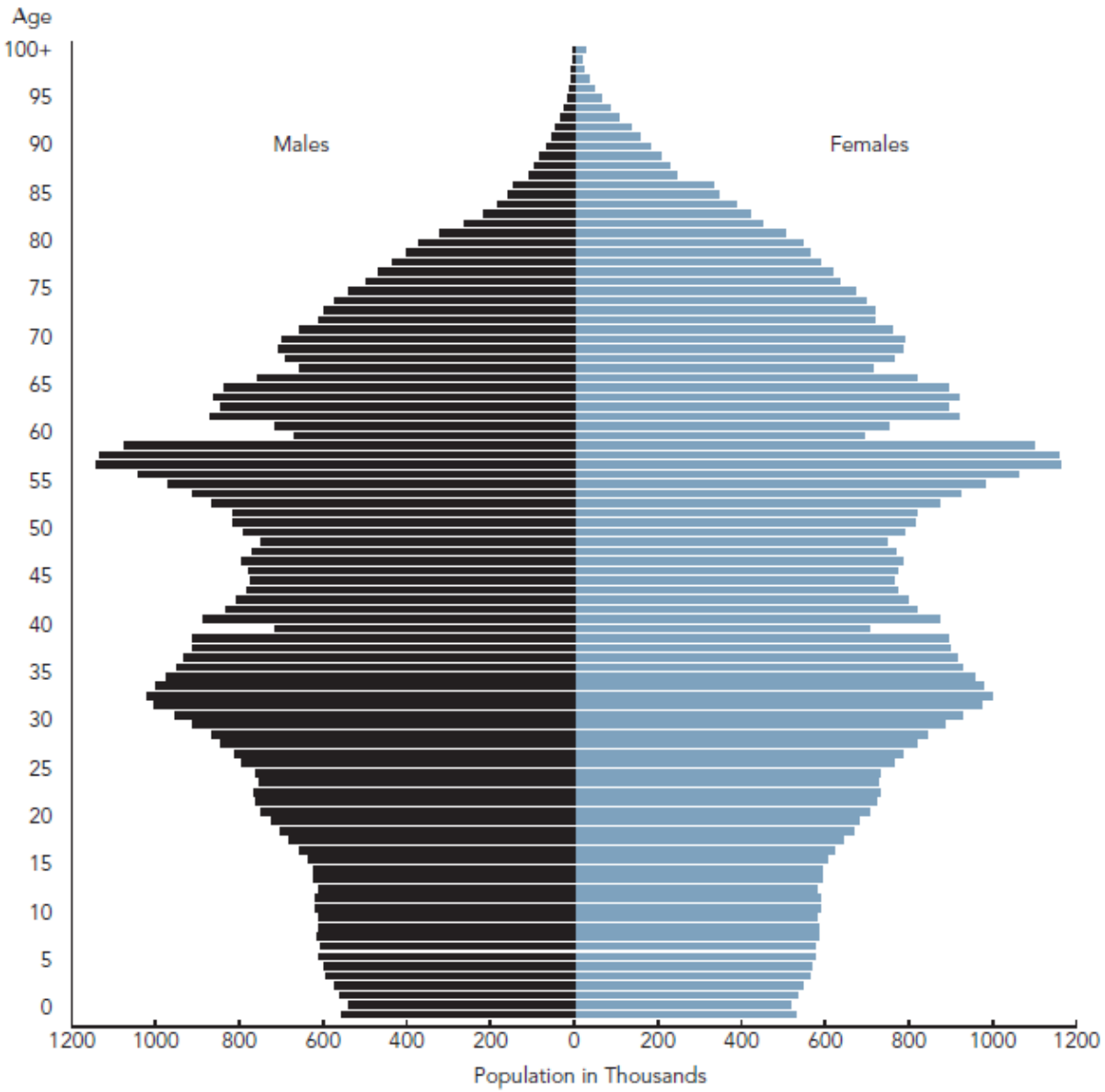
From pyramid to kite

Japan's population by age group, m



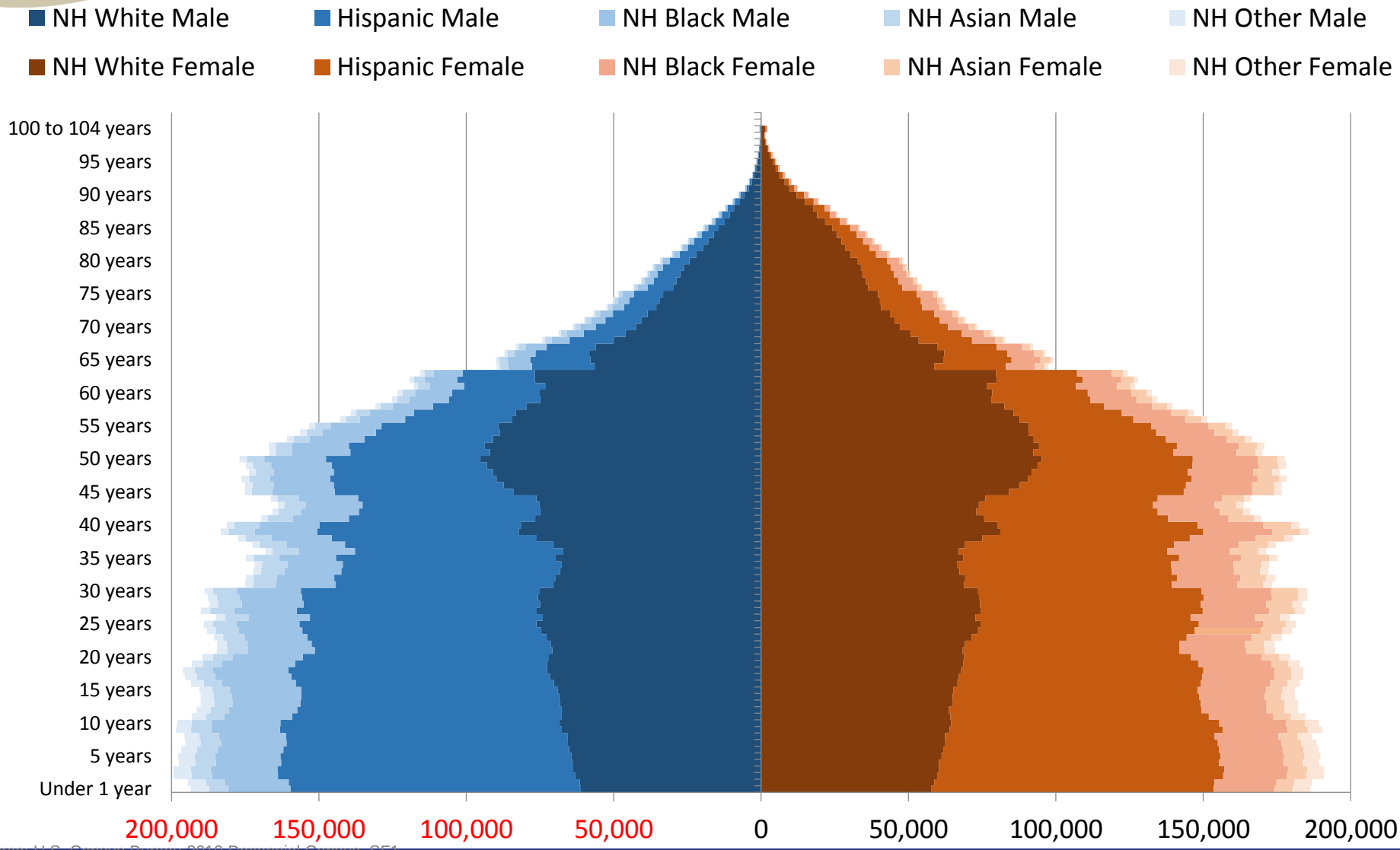
Source: National Institute of Population and Social Security Research

Population Pyramid of Japan, 2006



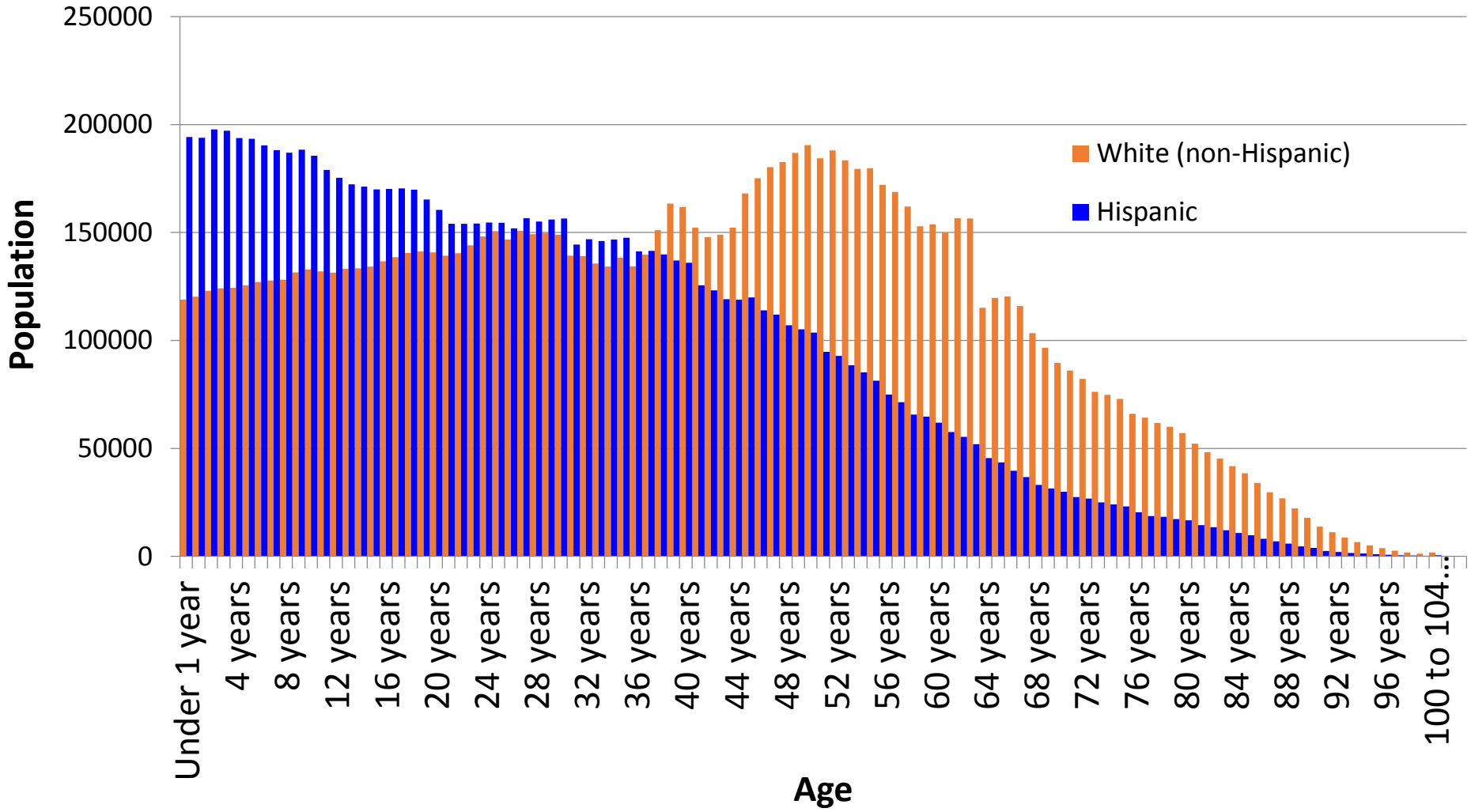
Source: Japan Statistics Bureau.

Texas Population Pyramid by Race/Ethnicity, 2010

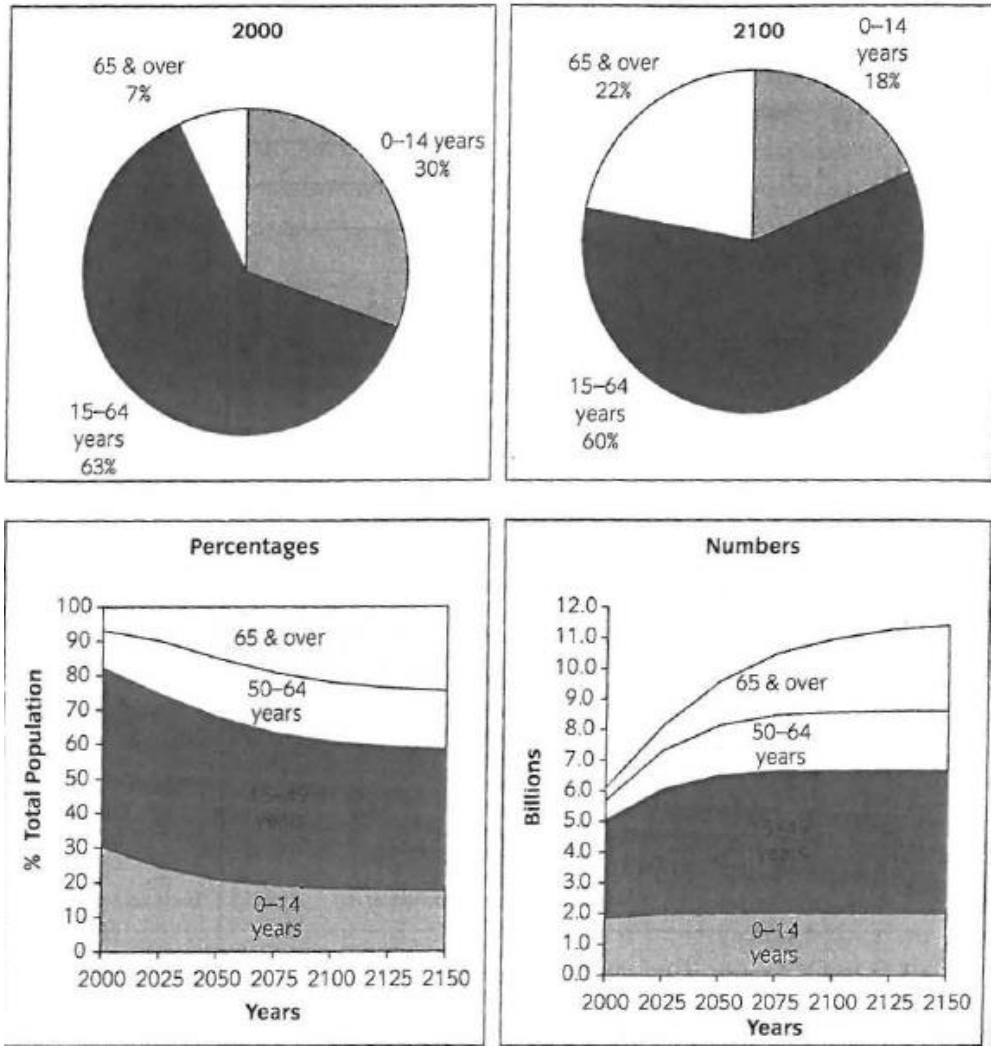


Source: U.S. Census Bureau 2010 Decennial Census, SF1

Texas non-Hispanic White and Hispanic Populations by Age, 2010



Source: U.S. Census Bureau 2010 Decennial Census, SF1


2000
65 & over
7%
0–14 years
30%
15–64
years
63%
2100
0–14
years
18%
65 & over
22%
15–64
years
60%
Percentages
% Total Population
100
90
80
70
60
50
40
30
20
10
0
65 & over
50–64
years
0–14
years
2000 2025 2050 2075 2100 2125 2150
Years
Numbers
Billions
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
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65 & over
50–64
years
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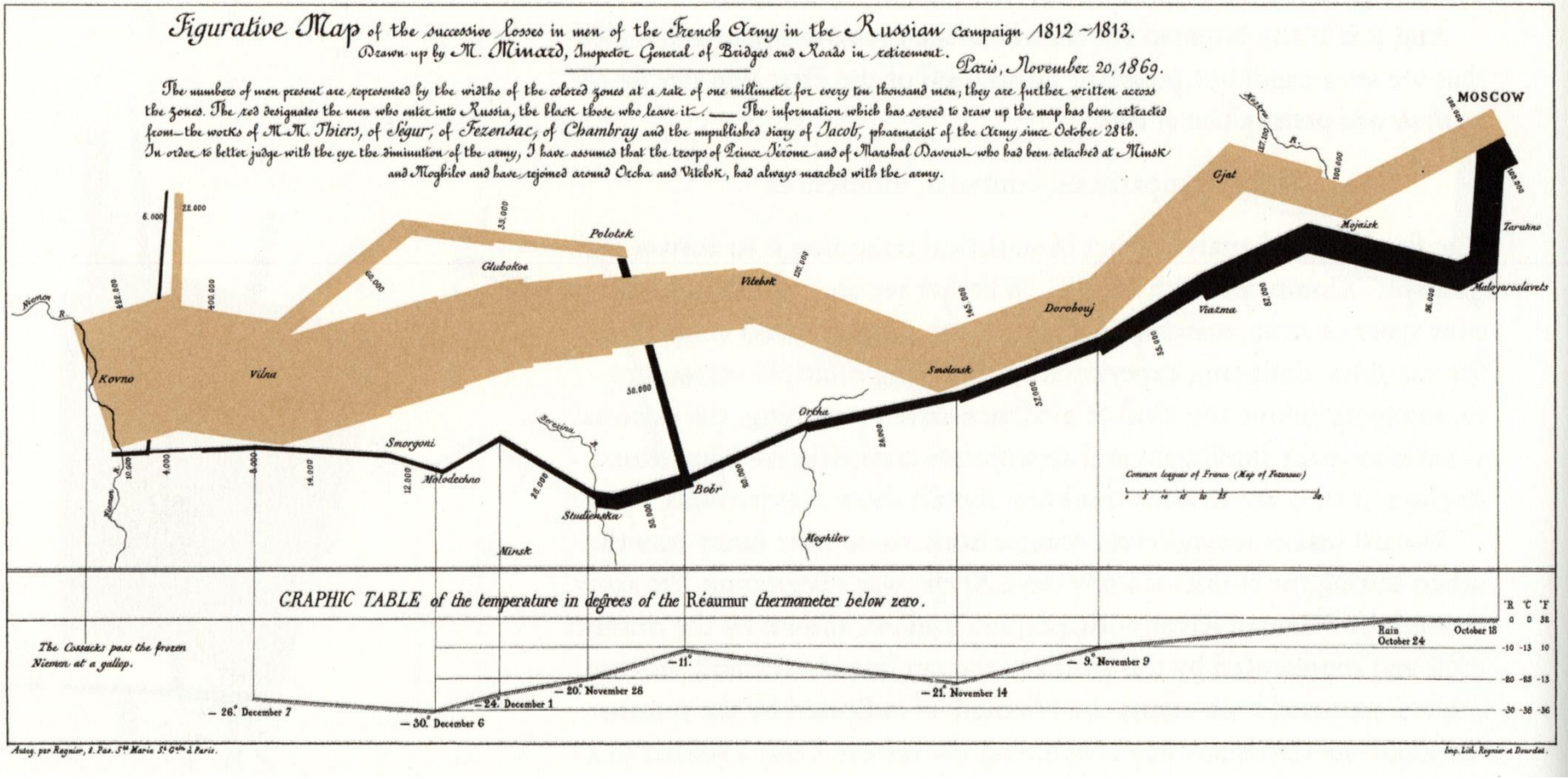
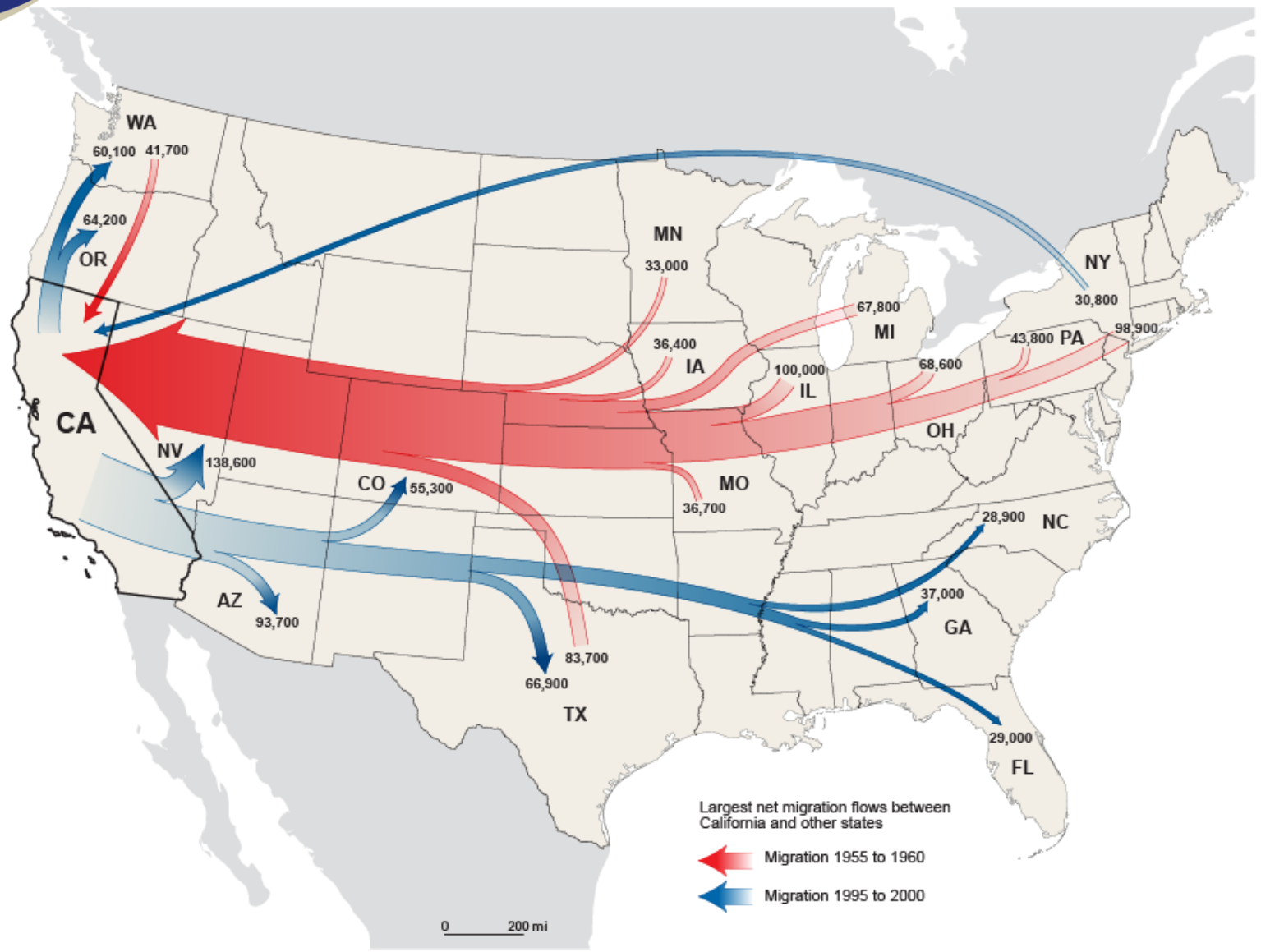
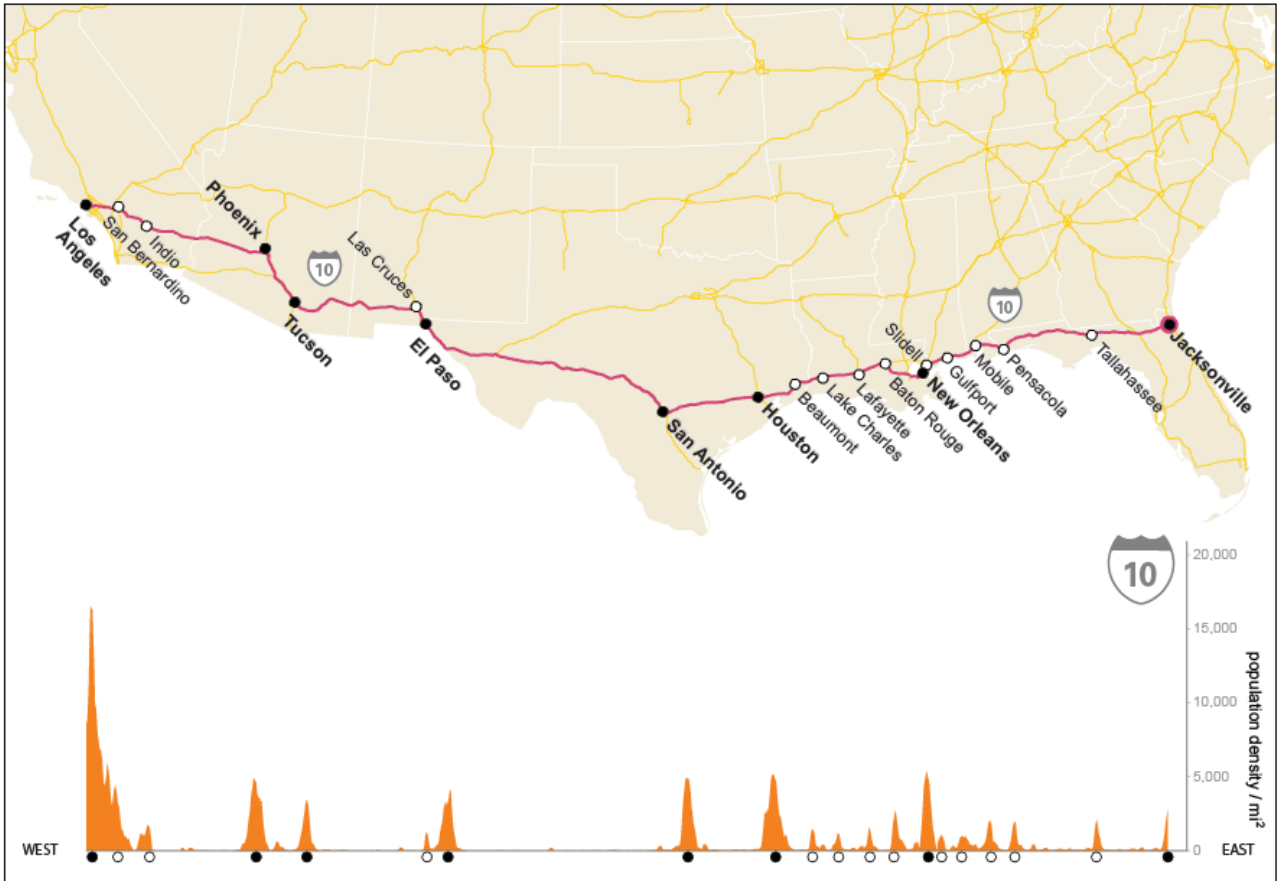
years
2000 2025 2050 2075 2100 2125 2150
Years


Figurative Map of the successive losses in men of the French Army in the Russian campaign 1812 – 1813.
Drawn up by M. Minard, Inspector General of Bridges and Roads in retirement.
Paris, November 20, 1869.
The numbers of men present are represented by the widths of the colored zones at a rate of one millimeter for every ten thousand men; they are further written across the zones. The red designates the men who enter into Russia, the black those who leave it. The information which has served to draw up the map has been extracted from the works of M. M. Thiers, of Ségur, of Fezensac, of Chambray and the unpublished diary of Jacob, pharmacist of the Army since October 28th. In order to better judge with the eye the diminution of the army, I have assumed that the troops of Prince Jérome and of Marshal Davoust who had been detached at Minsk and Mogbilev and have rejoined around Orcha and Vitebsk, had always marched with the army.
Niemen R.
Kovno
Vilna
Smorgoni
Molodechno
Minsk
Studienska
Bobr
Berezina R.
Polotsk
Glubokoe
Vitebsk
Orcha
Dnieper R.
Smolensk
Doroboui
Viazma
Mojaisk
Cjat
MOSCOW
Taroutino
Malo-yaroslavets
Common leagues of France (Map of Peterson)
GRAPHIC TABLE of the temperature in degrees of the Réaumur thermometer below zero.
The Cossacks pass the frozen Niemen at a gallop.
– 26° December 7
– 30° December 6
– 24° December 1
– 20° November 28
– 11°
– 21° November 14
– 9° November 9
Rain October 24
October 18
°R °C °F
0 0 32
-10 -13 10
-20 -25 -13
-30 -36 -36
Autog. par Regnier, 8. Pas. St Marie St Gth à Paris.
Imp. Lith. Regnier a Bourdet.


WA
60,100
41,700
64,200
OR
CA
NV
138,600
CO
55,300
AZ
93,700
MN
33,000
36,400
IA
67,800
MI
100,000
IL
MO
36,700
OH
NY
30,800
43,800
PA
98,900
68,600
28,900
NC
37,000
GA
83,700
66,900
TX
29,000
FL
Largest net migration flows between California and other states
Migration 1955 to 1960
Migration 1995 to 2000
0
200 mi

I-10 Population Density Profile, 2010

October 11, 2012



Contact

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